POWER PLANT ENGINEERING

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Preparing Pittsburgh District Waters for Boilers

INTERMITTENT WATER-SOFTENING SYSTEMS REDUCE BOILER REPAIRS AND TURBINE TROUBLES IN PLANTS OF A. M. BYERS CO. AND W. J. RAINEY

WHEN THE LIQUID which is available for use in steam boilers is not water but a changing solution of several scale-forming substances with a liberal percentage of free acid and undissolved organic matter, no end of boiler troubles will be encountered if some means are not provided for keeping the incrusting solids out of the boilers, or at least changing them to the non-incrusting type. That is virtually the condition which exists in the Pittsburgh district and it is constantly getting more complicated as the industry of the district increases with corresponding increasing pollution of the neighboring streams.

The Monongahela River water, for example, has rapidly changing characteristics which cannot be predicted, due to the sources of the impurities. Water pumped from mines into the river is highly charged with sulphates, and the industrial, pickling, and by-product coke plants which line the river's banks for miles, have a contaminating refuse water discharging at varying intervals and in varying quantities into the river. Acid waters from various plants dissolve the rocks of the river bed thus increasing the scale-forming

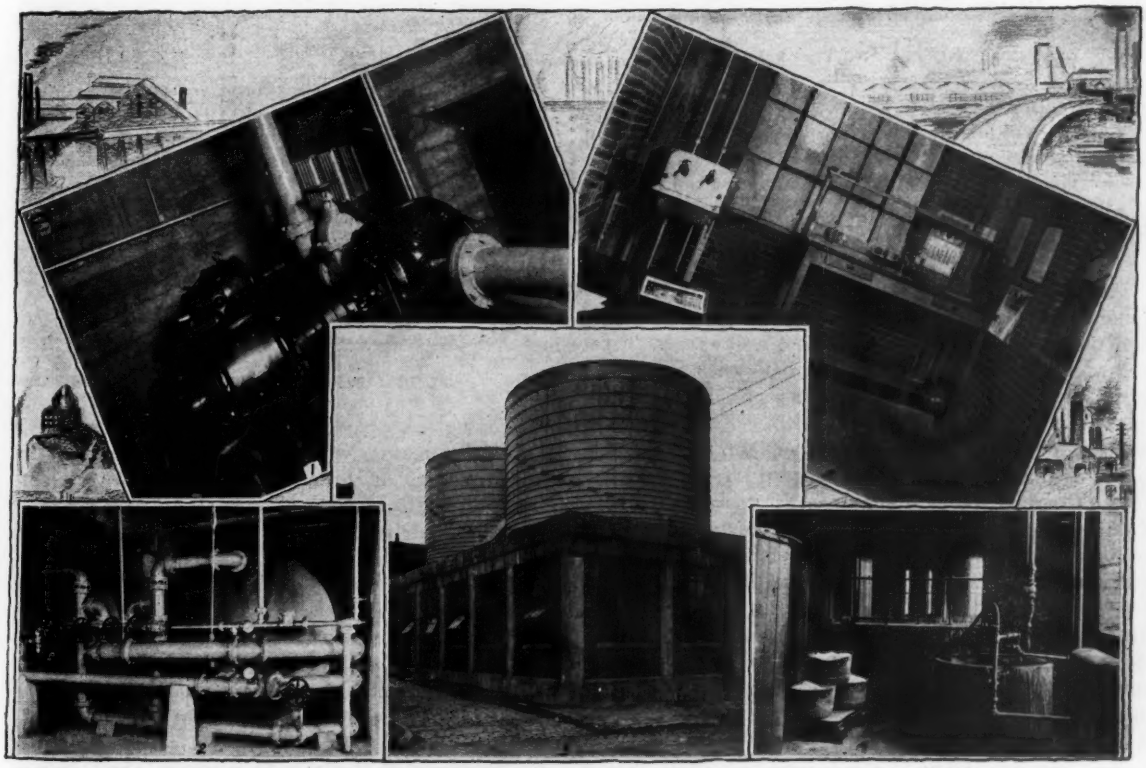


FIG. 1. MOTOR-DRIVEN PUMPS IN THE BYERS PLANT. FIG. 2. VIEW OF PRESSURE FILTERS AND STEAM JET FOR CLEANING. FIG. 3. EXTERIOR VIEW OF BYERS WATER-SOFTENING PLANT. FIG. 4. REAGENT MIXING TANK. FIG. 6. ATTENDANT'S OFFICE WHERE SAMPLING AND TESTING IS DONE.

contents. Add to this the increasing volume of sewage with its organic matter, and the problem of preparation for boiler use becomes extremely complicated.

The characteristics of the water fluctuate somewhat with the seasons, the greatest difficulty being experienced in summer when the water is low and concentrated. At this time of year analyses have shown a free sulphuric acid content as high as 50 parts per 1,000,000. Strange as it may seem, the water is best for boiler feed purposes when it carries the most dirt in suspension, for at this time it contains the most surface water which dilutes the acid content and the solids in solution.

The method of preparing such water as this for boiler feeding necessarily involves frequent testing and chang-

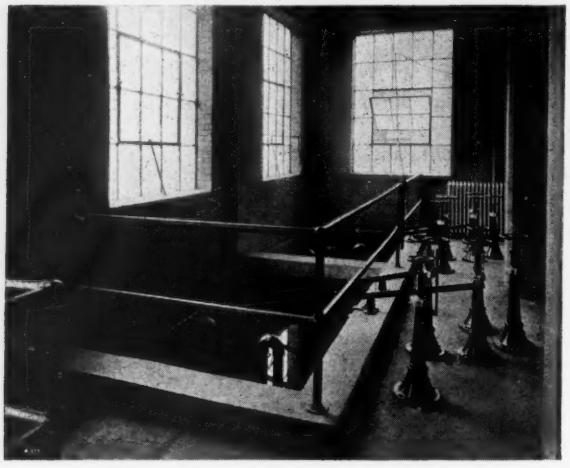


FIG. 5. FILTERS AND FLOAT VALVES

ing of treatment to suit the varying conditions of the water, and in the intermittent system which has been adopted at the plant of the A. M. Byers Co. in Pittsburgh and at the mine and coke plant of W. J. Rainey at Allison a satisfactory solution has been found.

EQUIPMENT AT BYERS PLANT

AT THE Byers plant, water is taken directly from the Monongahela River and used as condensing water in jet condensers, being delivered to the hot well at a temperature of about 70 deg. From the hot well two motor-driven turbine pumps, one held in reserve, deliver either to the softening or filtering system. Each of these pumps has a capacity of 1100 gal. per min. running at a speed of 1120 r.p.m., against a head of 75 ft. The motors to which these pumps are direct connected are of 45 hp. capacity, and run on direct current at 230 v.

As intimated above, the water coming from the hot well is used for two purposes: part of it passes through a pressure filter and is used in the hydraulic presses throughout the mill where scale-forming impurities are not a detriment, but where suspended matter in the water causes excessive wear on valves, pistons and packing; the remainder goes to the softening system where it is treated for boiler use.

The pressure filter, divided into two units, has a total capacity of 700 g.p.m. These are so connected by piping that either one may be bypassed and cleaned without interfering with the operation of the other. The filtering material used is gravel, crushed quartz and sand which is cleaned by reversing the flow of water through the filter bed and aerating it by means of a steam ejector shown in the foreground of Fig. 2. Washing is done for 15 min. each day at noontime. Water to be filtered is first treated with alum by passing a portion of it through a closed tank filled with alum crystals which dissolve and form a coagulant for the suspended matter in the water as it enters the filter.

Water for use in the boilers of the power plant is treated in an intermittent system; the process outlined briefly is to add to the water as it enters the settling tank, the proper chemicals either to precipitate the scale-forming impurities, or to change them into impurities that are of the non-incrusting character, or to do both, depending upon the character of the impurities, also to neutralize the free acid content of the water. In the settling tanks, of which there are two in this plant used alternately, the treated water is first stirred, then allowed to stand for 2 to 6 hr., depending upon the load being carried, during which time the precipitates settle to the bottom of the tank. When complete settling has taken place, the water is drawn off from the top and passed through a filter to the clear well from which it is pumped to the feed-water heater and boilers.

In this particular case, the two settling tanks are located on the roof of the building used exclusively for treating the water. Each tank has a capacity of 80,000 gal. and the plant is designed for softening 20,000 gal. of water an hour.

REPORT SHEET FOR WATER SOFTENING AND PURIFYING SYSTEM

Plant A. M. BYERS COMPANY Date March 24, 1920 128

3-24	#2	0;25P	6;25P;25DA	6;45A	40	20	104	Y	2.6	2.3	1.9	1.4	?	2.7	2.1	2.3	2.3	1.4
3-25	#1	12;40A	3;5DA;45A	5DP	41	20	105	Y	2.7	2.4	2.0	1.4	?	2.9	2.4	2.4	2.0	1.6
3-25	#2	6;00A	3;20A;50P	10;05P	45	22	114	Y	2.4	2.9	1.9	1.0	?	2.2	4.9	2.1	2.2	1.2
3-26	#1	9;45A	3;5DP;40A	6;00A	44	22	112	Y	2.0	2.7	2.3	1.4	?	4.1	2.4	2.2	2.2	1.2
3-26	#2	10;15P	2;50P	5;40A	40	20	106	Y	2.0	2.2	2.1	1.4	?	2.2	4.0	2.2	2.4	1.2
3-26	#1	4;30A	7;10A	6;40P	39	20	110	Y	2.5	2.0	2.0	1.0	?	2.5	4.2	2.2	2.4	1.4
3-26	#2	12;30P	2;05P	4;40P	40	20	109	Y	2.2	2.7	1.9	1.0	?	2.2	4.2	1.9	2.0	1.2
3-27	#1	6;40P	8;25P;40A	6;45A	40	20	108	Y	2.6	2.2	2.0	1.2	?	2.6	4.2	2.2	2.6	1.4
3-27	#2	1;50A	8;25AP;45A	5;40P	40	20	109	Y	2.2	2.9	1.7	1.2	?	2.4	4.2	1.9	2.0	1.2
3-27	#1	6;50A	10;30AP;50P	6;00P	42	20	105	Y	2.2	2.2	1.8	1.0	0	2.2	4.2	2.2	2.0	1.0
3-27	#2	4;00P	9;25PP;00AP;30P		42	20	111	Y	2.2	2.0	2.0	1.0	?	2.2	4.6	2.0	2.6	1.6
3-28	#1	4;50P	6;30PP;25PP;30A		42	20	110	Y	2.2	2.2	2.1	0.8	0	2.2	4.2	2.6	1.2	1.0
3-28	#2	7;25P	11;40PP;30AP;30P		42	20	110	Y	2.4	2.7	1.9	0.8	0	2.2	4.1	2.2	1.2	1.0
3-29	#1	4;30A	9;00AP;30PP;00P		43	20	123	Y	2.7	2.6	1.9	1.6	?	2.6	5.1	2.1	2.0	1.4
3-29	#2	12;40P	2;10PP;00PP;25A		44	20	123	Y	2.2	2.1	1.6	1.6	0	2.6	4.2	2.1	2.2	1.2
3-29	#1	7;00P	3;40PP;25AP;45A		47	20	127	Y	2.6	2.1	2.1	1.0	?	2.2	5.0	2.6	2.4	1.6
3-30	#2	4;30A	3;25AP;45AP;45P		46	20	128	Y	2.4	2.2	2.0	0.8	?	2.2	2.2	2.4	2.2	2.0
3-30	#1	9;30AP	3;25AP;45P;20A		46	20	122	Y	2.2	2.7	1.7	1.0	0	2.2	4.6	2.6	2.2	1.2
3-30	#2	4;30P	6;30P;20AP;30A		48	17	128	Y	2.1	2.6	1.6	1.0	0	2.4	4.2	2.2	2.2	1.2

Remarks:

Hedge removed from [illegible] 3-25-20 (1 & 2)

Filters Washed 3-25-20 (1 & 2) 3-29-20 (1 & 2)

FIG. 7. TYPICAL REPORT SHEET FOR SOFTENING PLANT

Placing the tanks over the building permits the location of the motors which drive the stirring paddles in the main room of the plant where they are under constant observation. The motors are 5 hp. each run at 1100 r.p.m., but drive the paddles at 5 r.p.m through a reduction gear.

Water to be treated is fed in through a pipe with the discharge near the top of the tank while the reagent is fed in through a separate pipe. The outlet is through a pipe provided with a swinging joint near the edge of the tank, the inlet end of the pipe being held just below the surface of the water by means of a large float.

The reagents used in this case are lime, to care for the bicarbonates (temporary hardness) and free acid; soda ash, to treat for permanent hardness and react with soluble lime salts formed; and ferrous sulphate in sugar form, to act as a coagulant, facilitating settlement.

These reagents are separately weighed out in proper quantities and mixed with hot water in a mixing tank shown in Fig. 4 and fed to the settling tanks by means of a steam ejector. The lime is fed at the same time that the water to be treated is flowing to the tank. After sufficient time has elapsed for reaction to take place the

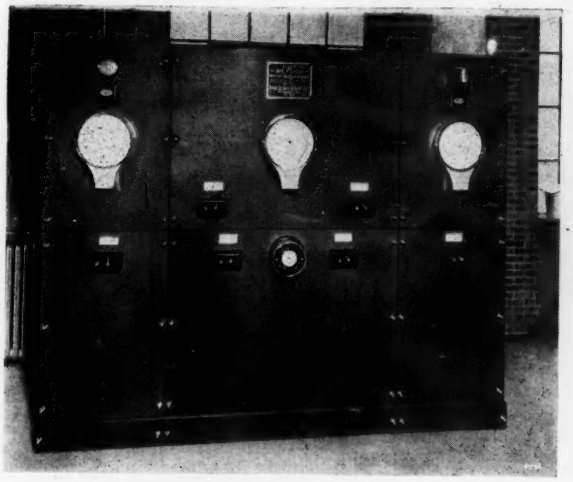


FIG. 9. GAGE AND SWITCHBOARD

ferrous sulphate is added and following a thorough mixing a test sample is drawn and the soda ash is added and another test sample drawn after sufficient time for the chemical reaction to take place.

The samples taken are tested as a guide for treating the next tank of water. The accompanying report sheet for March 24 shows how the treatment varied during the day in maintaining practically constant conditions in the treated water. While the results show some variations, the tests are very delicate and the slightest variations in chemical conditions show up perceptibly

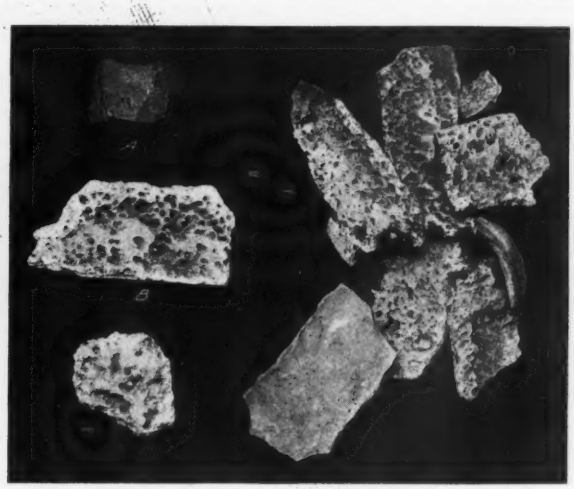


FIG. 11. SAMPLES OF SCALE TAKEN FROM BOILERS IN BYERS PLANT

in the results obtained. Complete analyses of the untreated and treated water are made at periodic intervals to check the results indicated by the operator's tests. A copy of one set of test analyses is reproduced herewith

TECHNICAL WATER ANALYSIS

ANA. No. 7245 DATE 4-19-20

FOR A. M. Byers Company, Pgh., Pa.

SOURCE OF SUPPLY Monongahela River WATER FROM Pittsburgh, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.65	Volatile and Organic Matter	.65
Silica	.85	Silica	.85
Iron and Alumina Oxides	.48	Iron and Alumina Oxides	trace
Calcium Oxide	2.24	Calcium Carbonate	
Magnesium Oxide	.96	" Sulphate	5.44
Sodium Oxide	.37	" Chloride	
Sulphuric Anhydride	5.68	" Nitrate	
Carbonic Anhydride (Fixed)	none	" Hydrate	
Carbonic Anhydride (Free)	.87	Magnesium Carbonate	
Chlorine	.50	" Sulphate	2.64
Nitric Anhydride	.11	" Chloride	.09
Nitrous Anhydride		" Nitrate	.15
Hydrate Water		" Hydrate	
		Sodium Carbonate	
		" Sulphate	
		" Chloride	.70
		" Nitrate	
		" Hydrate	
Acidity as H_2SO_4	.29	Ferrous Sulphate	.91
Alkalinity as $CaCO_3$			
PHYSICAL EXAMINATION		Total Solids	11.43
Turbidity (Silica Standard)		Suspended Matter	3.85 x
Color (Platinum Cobalt Std.)		Free Carbonic Acid	.87
		Sulphuric Acid	.29

Incrusting Solids 10.08 Grains per U. S. Gallon
Non-Incrusting Solids .70 " " " "

REMARKS: x Nature of suspended matter: mostly iron, silica and organic matter.

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
A Per C.

TECHNICAL WATER ANALYSIS

ANA. No. 7246 DATE 4-19-20

FOR A. M. Byers Company, Pgh., Pa.

SOURCE OF SUPPLY #7245 treated WATER FROM Pittsburgh, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.25	Volatile and Organic Matter	.25
Silica	.45	Silica	.45
Iron and Alumina Oxides	trace	Iron and Alumina Oxides	trace
Calcium Oxide	.36	Calcium Carbonate	.65
Magnesium Oxide	.12	" Sulphate	
Sodium Oxide	7.81	" Chloride	
Sulphuric Anhydride	6.48	" Nitrate	
Carbonic Anhydride (Fixed)	1.14	" Hydrate	
Carbonic Anhydride (Free)	none	Magnesium Carbonate	
Chlorine	.67	" Sulphate	
Nitric Anhydride	.11	" Chloride	
Nitrous Anhydride		" Nitrate	
Hydrate Water	.32	" Hydrate	.17
		Sodium Carbonate	2.06
		" Sulphate	11.50
		" Chloride	1.11
		" Nitrate	.17
		" Hydrate	1.20
Acidity as H_2SO_4			
Alkalinity as $CaCO_3$	4.40		
PHYSICAL EXAMINATION		Total Solids	17.56
Turbidity (Silica Standard)		Suspended Matter	trace
Color (Platinum Cobalt Std.)		Free Carbonic Acid	none

Incrusting Solids 1.27 Grains per U. S. Gallon
Non-Incrusting Solids 16.04 " " " "

REMARKS:

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
B Per C.

FIG. 8. WATER ANALYSES BEFORE AND AFTER TREATMENT AT BYERS PLANT

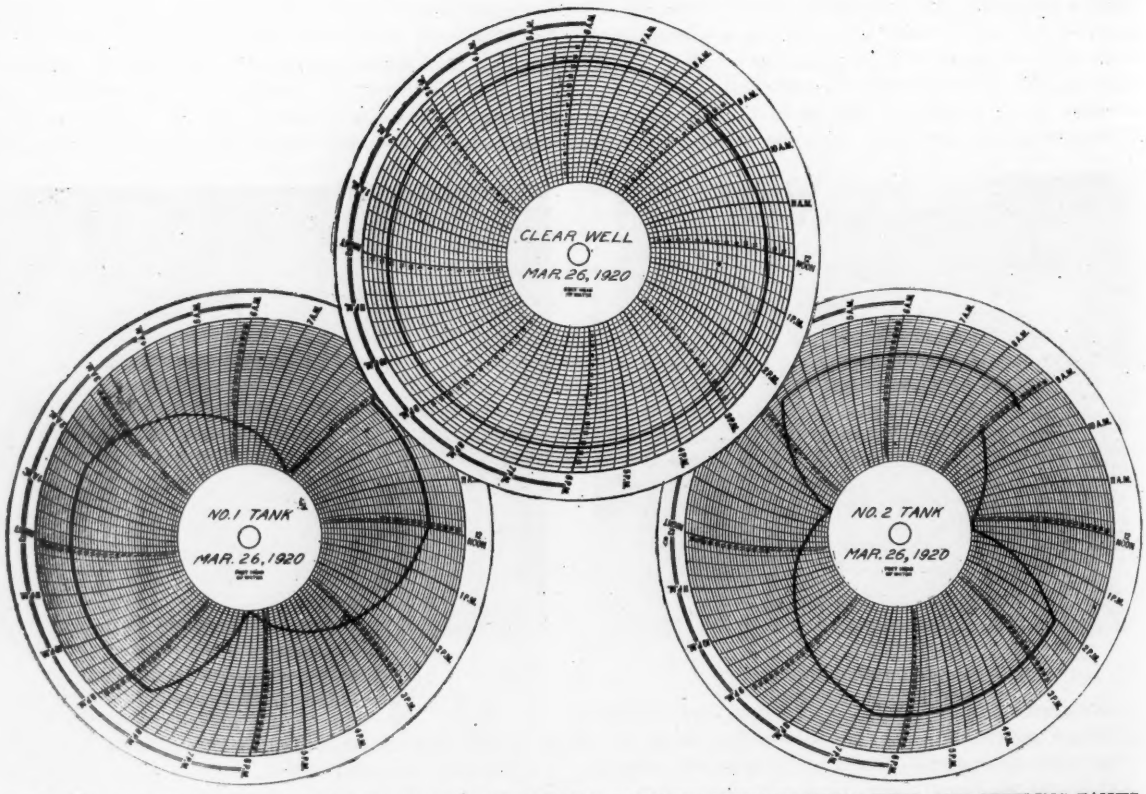


FIG. 10. TYPICAL GRAPHIC RECORDS SHOWING VARIATIONS IN WATER LEVEL IN CLEAR WELL AND SETTLING TANKS

TECHNICAL WATER ANALYSIS

ANA. No. 7020 DATE 7-24-19

FOR W. J. Rainey,
Uniontown, Pa.

SOURCE OF SUPPLY Reservoir WATER FROM Allison, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.65	Volatile and Organic Matter	.65
Silica	.75	Silica	.75
Iron and Alumina Oxides	trace	Iron and Alumina Oxides	trace
Calcium Oxide	2.02	Calcium Carbonate	2.00
Magnesium Oxide	.64	" Sulphate	2.16
Sodium Oxide	.37	" Chloride	
Sulphuric Anhydride	2.16	" Nitrate	
Carbonic Anhydride (Fixed)	.68	" Hydrate	
Carbonic Anhydride (Free)	.26	Magnesium Carbonate	
Chlorine	.57	" Sulphate	1.32
Nitric Anhydride	.32	" Chloride	.19
Nitrous Anhydride		" Nitrate	.44
Hydrate Water		" Hydrate	
		Sodium Carbonate	
		" Sulphate	
		" Chloride	.70
		" Nitrate	
		" Hydrate	
Acidity as H_2SO_4			
Alkalinity as $CaCO_3$	2.00		
PHYSICAL EXAMINATION			
Turbidity (Silica Standard)		Total Solids	8.23
Color (Platinum Cobalt Std.)		Suspended Matter	8.75
		Free Carbonic Acid	.25

Incrusting Solids 6.88 Grains per U. S. Gallon
Non-incrusting Solids .70 " " "

REMARKS:

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
By C.

A

TECHNICAL WATER ANALYSIS

ANA. No. 7021 DATE 7-24-19

FOR W. J. Rainey,
Uniontown, Pa.

SOURCE OF SUPPLY #7020 Treated WATER FROM Allison, Pa.

DETERMINED	GRAINS PER U. S. GALLON	PROBABLE COMBINATIONS	GRAINS PER U. S. GALLON
Volatile and Organic Matter	.45	Volatile and Organic Matter	.45
Silica	.45	Silica	.45
Iron and Alumina Oxides	trace	Iron and Alumina Oxides	trace
Calcium Oxide	.34	Calcium Carbonate	.60
Magnesium Oxide	.28	" Sulphate	
Sodium Oxide	4.77	" Chloride	
Sulphuric Anhydride	2.72	" Nitrate	
Carbonic Anhydride (Fixed)	1.06	" Hydrate	
Carbonic Anhydride (Free)	none	Magnesium Carbonate	
Chlorine	.57	" Sulphate	
Nitric Anhydride	.32	" Chloride	
Nitrous Anhydride		" Nitrate	
Hydrate Water	.38	" Hydrate	.41
		Sodium Carbonate	1.91
		" Sulphate	4.83
		" Chloride	.94
		" Nitrate	.51
		" Hydrate	1.12
Acidity as H_2SO_4			
Alkalinity as $CaCO_3$	4.60		
PHYSICAL EXAMINATION			
Turbidity (Silica Standard)		Total Solids	11.22
Color (Platinum Cobalt Std.)		Suspended Matter	trace
		Free Carbonic Acid	none

Incrusting Solids 1.46 Grains per U. S. Gallon
Non-incrusting Solids 9.31 " " "

REMARKS:

Respectfully submitted,
WM. B. SCAIFE & SONS CO.
By C.

B

FIG. 12. TYPICAL ANALYSES BEFORE AND AFTER TREATMENT OF WATER USED IN RAINEY PLANT

showing that the incrusting solids have been reduced from 10.08 grains per gallon to 1.27 grains. Non-incrusting solids are held in suspension until the water in the boiler becomes concentrated, at which time the boiler should be blown down to reduce the concentration and also to prevent precipitation, so along with the chemical treatment of the water go instructions to the water tender regarding frequency with which boiler blowoff valves should opened.

The treated water flows by gravity from the settling tanks to the filters, of which there are two and which have a combined capacity of 80,000 gal. in 4 hr. Water to the filters is controlled by a float-operated valve so that the filter bed is always covered, but the containers never overflow. Likewise another float-operated valve prevents flow from the filter to the clear water tank when it has become filled, the surface level of the clear water tank varies from 11 to 13 ft. below that of the filters.

The filters are washed twice a week, which is done by reversing the flow of water through the filter bed supplemented by air and steam forced through the bed by a steam ejector. The wash water forced up through the quartz is carried away through troughs acting as skimmers located above the surface of the bed. As an indication of the condition of the filter, a record is kept of the difference in water level between that in the filter and that in the clear water tank; this difference increases as the filter gets fouled and is never allowed to increase more than 2 ft. before cleaning is done.

To prevent overflow of the filter tanks, an overflow pipe is provided and, in addition, a high water alarm calling attention to the condition.

The clear water tank is located under the floor of the plant and has a capacity of 160,000 gal. This tank, as well as the filter tanks and floor, is constructed of reinforced concrete, which has given perfect satisfaction.

Essential to the convenient operation of the treating plant is the gage board, which, as shown in Fig. 9, consists of three panels on which are mounted recording pressure gages for each of the settling tanks, which show the water level in each, another recording gage shows the head of water in the clear well; high water alarm bells of different tones for each of the tanks; push-button switches for each of the stirring motors; the two raw water pumps and two feed water pumps with an indicating light showing when the feed water pumps are in operation; and an integrating wattmeter measuring the power used by the treating plant.

Water which has been softened is used in the boilers of the power plant which furnishes all the power used in operating the company's wrought iron pipe mill and a very complete record was kept for several years prior to the installation of the system in order to determine the advisability of making the investment. The accompanying tabulation is of interest as showing how thoroughly the records are being kept, and the loss of time due to poor water.

The total rated boiler horsepower of the plant is 3875, which is divided among five 500-hp. horizontal water-tube boilers fired with coal, and three 250-hp. and five 125-hp. vertical water-tube boilers utilizing waste heat from the furnaces. The softening system, however, was designed for 5000 hp., as the horizontal boilers are stoker fired and are frequently operated at 150 per cent of their rating.

FIG. 13. TWO VIEWS IN THE OPERATING ROOM OF THE RAINEY WATER-SOFTENING PLANT

When the plant began using softened water, the boilers were heavily incrusted with hard scale, as it was impossible to keep them clean any length of time after they had been turbined, so only partial treatment was used to prevent the scale from coming down too rapidly and causing burned tubes. This treatment was gradually increased until the heating surfaces were free from scale. As a precaution, each boiler will be turbined every six months. In Fig. 11 is reproduced a photograph of samples of scale; A was taken from the boilers after six weeks' run before any treated water was used and B after softened water had been used one week, which shows a marked change in character. At times of cleaning, the average weight of scale removed from each boiler was 1800 lb., which was the accumulation of six weeks' operation. Of the five coal-fired boilers, which are 10 yr. old, the drums in four had to be replaced and continual tube trouble was experienced at a total cost for replacing tubes averaging $40 apiece. During the six months which the treating plant has been in operation, the tube replacements have been reduced to almost nothing and shutdowns on account of bad water have been totally eliminated.

Operating Data Affected by Water Condition

Horizontal B. & W. Boilers only (not accurate)	1917	1918	1919 (year)
Tubes removed	212	176	307
Tubes turbined	3276	3780	2776
Times Blowoff opened	891	4281	4042
Hours in Operation			(6 mo.)
Boiler No. 1	4880.25	4683	1290.5
Boiler No. 2	5445.5	2679.5	3303
Boiler No. 3	5980	5587.5	3022
Boiler No. 4	5839.75	5264.5	2355
Boiler No. 5	5225.75	5330	1916
Steam produced lb	340,608,472	204,075,970	

readily be appreciated by referring to the analyses given here of water before and after treatment.

In this plant, it had been customary to have a boiler down for cleaning every seventh week at which time the tubes were turbined, with the result that four to five wheelbarrow loads of scale were removed from each boiler, and in addition, frequent shutdowns were necessary for repairs and replacing tubes. Not alone in the boilers was scale trouble encountered, but in the steam pipe lines, valves, and particularly in the turbines. Continual turbine blade trouble was experienced, which required the replacement of parts and frequent shutdowns. These troubles were eliminated when the softening plant got into working order. It is still the practice

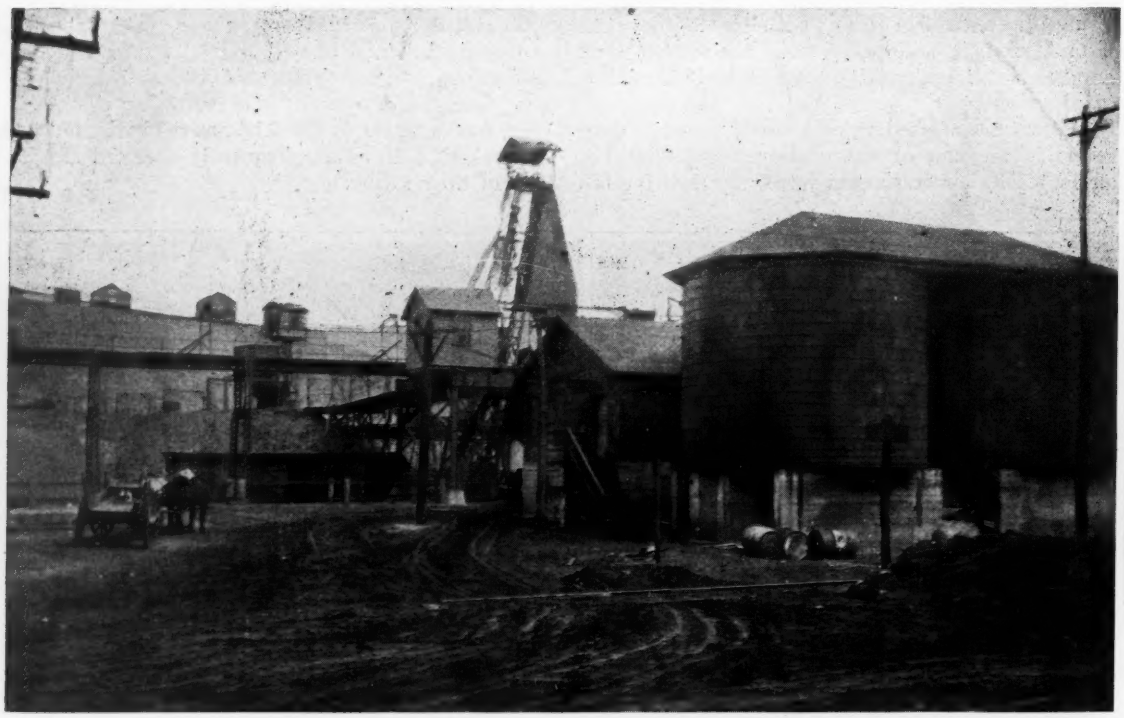


FIG. 14. ELEVATED COAL TRACK AND EXTERIOR OF SOFTENING PLANT AT ALLISON

Time Lost Due to Leaks in Waste Heat Boilers Affecting 21 Men Per Heat

Waste Heat Boilers	1917	1918	1919
Heats	99	40	....
Hours	198	80	....
Tubes removed	281	99	95

Rainey Plant

At the Allison plant of W. J. Rainey, the same type of softening system is employed as at the Byers plant; the size, however, is considerably smaller, each of the two settling tanks having a capacity of 48,000 gal. The water treated for use in the boilers comes from two sources. Back up in the hills the company has built a dam across a hollow, thus forming a reservoir which is fed by springs. As a supplement to this source, Monongahela River water is used. The water from neither source is fit for use in boilers without treatment, as will

to have each boiler down for cleaning every seventh week; but no scale accumulates, so they are only washed out thoroughly. The replacement of boiler tubes has been reduced to almost nothing. To prevent concentration in the boiler during operation, the blowoff valves are opened every 6 hr. which has been found to give most satisfactory results.

In the routine of operation of the softening plant, water taken from the storage reservoir is pumped into one of the settling tanks. At the same time, the lime solution is being delivered to the tank and the stirring paddles are kept in operation. The filling operation, with the equipment provided, requires about half an hour, and when the tank is full, the ferrous sulphate solution is put in and a test sample of the water is drawn a few minutes later. The soda ash solution is next delivered to the tank and the stirring continued for 15 min. The water is then allowed to remain quiet for 10 min. when another test sample is drawn. The two samples

are heated and tested and the results used as a guide to the amount of reagents to be used in treating the next tank of raw water. In this plant, the amount of soda ash used per day averages about 240 lb., lime 130 lb. and ferrous sulphate 120 lb.

After the stirring device has been stopped, the water is allowed to stand for at least 2¾ hr. before it is ready to be passed through the filter to the clear well. The present demands of the plant, however, are such that one tank full of water will last from 5½ to 6 hr. and when they increase beyond the capacity of the present installation, another settling tank and filter can readily be installed, as provision has been made for them in the layout of the plant.

In regular operation, the filter is washed twice a week by reversing the flow of water through the bed of quartz and aerating it by means of a steam air ejector. The sludge which settles at the bottom of the settling tanks is drawn off once a week. For the convenience of the operator and to prevent the waste of water through accident, the tanks and the filter are each provided with a high water alarm.

FIG. 15. FURNACE FRONTS AND DISTRIBUTING TYPE STOKERS AT RAINEY PLANT

On its way to the boilers from the clear well, the treated water is used for cooling air compressors and turbine bearings, whence it goes to a hot well tank, then to the feed-water heater and finally to the boilers.

Boiler Plant Equipment

Another interesting feature of this plant is the fact that a mixed fuel of coke breeze and bituminous coal is used for fuel in the proportion of about half and half. The coal comes directly from the mine operated by the company and the coke breeze is a by-product of the high-grade metallurgical coke, the making of which is the principal purpose of the plant.

In the preparation of the fuel, all the coke breeze available is used and additional fuel is made up of run of mine coal. The two are mixed together and then run through a crusher which breaks down the lumps so that they will pass through a 1-in. screen. From the discharge of the crusher, the fuel is carried by a bucket elevator to a hopper over an elevated track from which it is discharged to mine cars and drawn by a mine locomotive to the boiler room bunkers. These extend the entire length of the boiler room, giving them a capacity sufficient for a 24-hr. run, and discharge directly to the stoker hoppers.

Seven water-tube boilers are installed, each of 350 hp. rated capacity. The furnaces are of dutch oven type, two to each boiler, each having a dumping grate 6 by 8 ft. The stokers are of the distributing type, the spreading being done by a jet of steam and air, while the regulation of the amount of fuel used is adjusted by hand. Forced draft is employed under the grates, the air pressure being automatically controlled along with the damper position in accordance with the variation in steam pressure which is normally held at 150 lb.

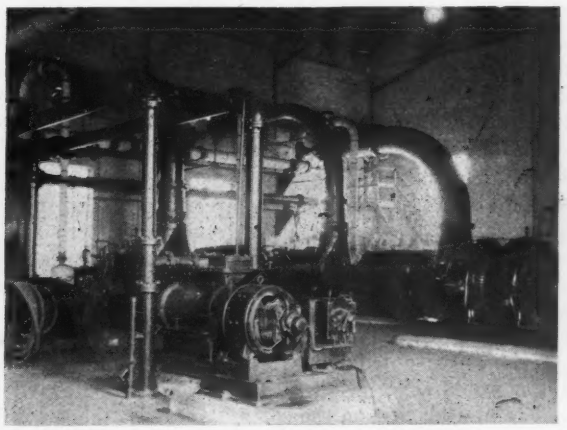


FIG. 16. ENGINE ROOM VIEW IN RAINEY PLANT

With this system, the furnaces are given no attention except for cleaning the fires once in 4 hr. and occasional leveling of the fuel bed. With hand firing, which was formerly employed, great difficulty with clinkering was experienced; but with the present system, the ash bed is porous and crumbles readily when barred before dumping. The ashpits are cleaned by drawing their contents into a mine cart drawn by a mule on tracks laid in the boiler-house basement to a skip hoist in the yard, where it is elevated to a bin from which it is dumped into wagons for disposal.

In the engine room of this plant, the generating equipment consists of three turbine units, one of 750 kw., the other two of 300 kw. capacity, delivering 3-phase current at 60 cycles and 2300 volts. Direct current used in the immediate vicinity is furnished by rotary converters. Several air compressors are also located in this room, some steam and others motor driven.

Until the water softening plant was put into operation, no end of trouble was experienced with scale and corrosion wherever the water or steam generated from

it was used, all of which has been eliminated with the installation of the new system.

In collecting the data used in the preparation of this article we are endebted to A. M. Byers Co., employes of W. J. Rainey, and Wm. B. Scaife and Sons Co. for courtesies extended and information furnished.

Smoke Problem at Salt Lake City

SULPHUR DIOXIDE AS A FACTOR IN THE SMOKE PROBLEM. BY G. ST. JOHN PERROTT, U. S. BUREAU OF MINES

IN AN investigation of methods of abating the smoke nuisance in Salt Lake City, the United States Bureau of Mines, in co-operation with the state of Utah and the city of Salt Lake, have collected samples of the atmosphere and analyzed them in an attempt to determine the part played by sulphur dioxide or smelter gases in polluting the air at Salt Lake City.

The Garfield smelter is 16 mi. west of the city, the Murray smelter 8 mi. south, and the Midvale smelter 12 mi. south. Under normal operating conditions, a relatively small amount of solid matter is discharged from the stacks of these smelters. The toxic gaseous constituent of the discharge is sulphur dioxide, which is discharged from the smelters the year round.

A fairly widespread opinion exists in Salt Lake City that the smelters contribute appreciably to the smoke nuisance. The gases, discharged from the smelter stacks, are believed (1) to float over the city in a heavy blanket which prevents the smoke from rising, and (2) to unite with the water vapor in the air to form corrosive fogs injurious to health and property. The first of these theories seems untenable. If the gas did not mix with air, it would sink, owing to its heavier specific gravity, and form a blanket on the earth. Actually, the gas diffuses rapidly in air and any part reaching Salt Lake must be thoroughly diluted. Perhaps sulphur dioxide, if in sufficient concentration, might aid in fog formation. The more obvious nuisance, however, would be the injury to health and vegetation. If the smelters are a factor in the city's smoke problem, the concentration of this gas in the air of the city should be appreciable and should increase toward the smelters, the concentration being highest with a south or a west wind.

Sulphur dioxide is a colorless gas with a pungent odor and acid taste. In sufficient concentration, it is injurious to animal life and vegetation. It is 2.2 times as heavy as air, but it diffuses readily with air and when once mixed does not again separate.

Extensive experiments have shown that concentrations of sulphur dioxide below 0.5 parts per million have no injurious effect on growing crops or vegetation. For injury to result with this concentration, continuous exposure throughout the growing period would be needed together with a high relative humidity, 80 to 100 per cent. A concentration of three parts per million is necessary before the average individual can detect its presence. Evidently the average concentration of sulphur dioxide in air must rise to 0.5 or 1 0 part per million before it can be considered an important factor in the pollution.

A total of 322 determinations were made during December, 1919, January, 1920, and March, 1920. Samples of air were taken in the heart of Salt Lake City and in the residence district.

The highest concentration noted, 0.8 parts per million, was on Dec. 15, at 9:30 a. m.; however, the average of the three samples of air taken at this point at that hour was only 0.25 parts per million. A maximum concentration of 0.6 per cent was observed on two days, Dec. 3, at 8 a. m., and Dec. 17, at 9:30 a. m., with averages for all the samples taken of 0.13 and 1.17 per cent. These three days, Dec. 3, 15 and 17, were very smoky and foggy with little wind. On four days, Dec. 4, Dec. 15, Jan. 16, and Mar. 12, a maximum concentration of 0.4 per cent was recorded. On one day, Dec. 5, a maximum of 0.2 was recorded; on two days, Jan. 27 and Mar. 13, a maximum of 0.1, and on the other 11 days when samples were taken (Dec. 10, Mar. 11, 15, 16, 22 and 31) none of the samples showed sulphur dioxide.

As above stated, the maximum concentration noted, 0.8 parts per million, was at 2d South and Main, Dec. 15 at 9:30 a. m., the day being foggy and smoky with little wind. The average of the 107 determinations made during December and January was 0.15 parts per million.

The 215 determinations made during March showed an average of 0.01 parts per million. The maximum amount noted was 0.4 parts per million on Mar. 12 at 9 a. m. on top of the Boston Building. Positive values were, as a rule, obtained only in the morning; the afternoon determinations were usually blank.

The following generalizations may be made from the data obtained: (1) The concentration of sulphur dioxide after 12 noon is usually smaller than 0.1 parts per million; the greatest concentrations occur before 10 a. m. (2) The highest concentration is observed in the business district. (3) Smoky days shown higher concentrations than clear days. (4) There is an inverse relation between wind velocity and concentration of sulphur dioxide but no apparent relation between the direction of the wind and the sulphur dioxide concentration. (5) The average concentration during December and January was about 0.15 parts per million, during March about 0.01 parts per million.

The data go to show that the sulphur dioxide in the air of Salt Lake City is largely a result of the combustion of fuel. At least 15 tons of this gas are sent into the atmosphere daily from the stacks of the city. The concentrations observed seem to bear a definite relation to the amount of smoke present.

The concentration of sulphur dioxide was at no time large enough to be an important factor in polluting the atmosphere of the city, and is less than that observed in other large cities. As high as 6 parts per million has been observed in London, 0.5 to 0.7 parts in Berlin, and 1.8 parts in San Francisco.

The concentration of SO_2 in Salt Lake City diminishes practically to zero in the residence districts on all sides of the business district. If the smelters were a factor, the concentration should be higher to the south and west; such is not the case.

TESTS AT HIGHER LEVELS

TO TEST the theory that a blanket of sulphur dioxide gas existed over the city, analyses of the upper strata of the atmosphere were made from an aeroplane.

The flight took place on Nov. 9, beginning at 11 a. m. and ending at about 11:30 a. m. The day was cloudy with a southwesterly wind of about 4 mi. per hour. This wind was in the direction to bring gas from the Garfield smelter. The temperature was 32 deg. F. The top of the smoke cloud at 11 a. m. was about 2000 ft. above the city.

Three samples were taken, the first one at an elevation of 2200 ft. above the city, the second at about 3000 ft. and the third at 1000 ft. The results were as follows:

Elevation	Concentration of SO_2 in parts per million
3000 ft.	0.0
2200 ft.	0.2
1000 ft.	0.0

The data collected are meager, but they serve to show that no heavy blanket of sulphur dioxide of high concentration was hanging over the city on Nov. 9 at any level below 3000 ft. The day was typically smoky, and undoubtedly conditions were not radically different from any other smoky day in winter.

Summary

1. An average of 107 determinations during December and January showed 0.15 parts per million of sulphur dioxide; an average of 215 determinations during March showed 0.01 parts per million of sulphur dioxide.
2. The concentration is highest on smoky days, in the morning, and in the business district. On clear and windy days and in the residence district on all sides of the city, the concentration is low.
3. The combustion of fuel in the city is in great part responsible for the sulphur dioxide present.
4. Neglecting consideration of the source of sulphur dioxide in the city's air, it is present in such small concentration as to be a negligible factor in the smoke nuisance.
5. Tests at levels up to 3000 ft. above the city showed only a trace of sulphur dioxide.

Centrifugal Pumps

A Brief Study of Their Characteristics, Tests and Methods of Driving

BEFORE PURCHASING or recommending a centrifugal pump for given conditions, it is necessary to know the performance of the pump under various conditions of operation. We need to know the amount of water it will deliver, the head that it will produce together with the efficiency and horsepower at varying loads. These points can best be illustrated graphically by means of a set of curves known as the characteristics of the pump, which are plotted from data obtained by an actual test of the pump under consideration. Usually they comprise the three curves expressing the variation in head, the efficiency, and the brake horsepower; but, broadly speaking, any of the curves expressing the relation between head, speed, discharge, and horsepower may be termed pump characteristics, regardless of the variable against which they are plotted.

Discussion of Characteristics

In order properly to discuss the significance of the characteristics, let us suppose we had run a test on a pump and had obtained the following data:

Point	G.P.M.	Total Head in Feet	Per Cent. Efficiency	B.H.P.	R.P.M.
1	0	111	0	28	1420
2	400	114	30	38	1420
3	800	114	52	44.5	1420
4	1200	110.5	65.5	51	1420
5	1600	102	72.5	56.5	1420
6	1800	95	73.2	58.5	1420
7	2000	86	72.5	60	1420
8	2200	76.5	70	61	1420

From this data we plot the curves shown in Fig. 1.

Head Curve

This curve which is drawn by plotting the different heads against the gallons per minute makes possible the determination of the intermediate capacities and heads not obtained from test readings. For example, the head developed when the pump is delivering 1300 g.p.m. is 110 ft. This is done by projecting vertically upward from the gallon per minute scale to the head curve and then across horizontally to the head scale at the left.

It will be seen that as the head is reduced, the output increases, but this is only true within reasonable limits. If the head is reduced to zero, a condition never obtained in actual practice, the pump could not deliver more than 2400 g.p.m. The highest point on the curve is 114 ft.; it is therefore evident that the pump could not be used for a greater head than this, as it would deliver no water, the speed remaining constant. At zero gallon per minute the head is 111 ft. This indicates that even if the discharge valve is closed entirely, the pressure would rise no higher, and that the pump would not be damaged by this condition. The pressure would probably rise a trifle higher than 111 ft. on account of the slight increase in the speed of the driving motor which takes place at "shut off."

The slight rise in the head curve from zero to 800 g.p.m. is explained by the fact that as soon as water actually begins to flow through the pump, a greater pressure is generated, due to the transformed velocity energy. This increase in pressure further indicates that not only the impeller, but the volute waterway of the casing as well, have been scientifically designed for the proper conversion of kinetic energy.

The curve illustrated is a good average head curve for a general service pump. If a variable head is encountered and a minimum variation in capacity desired, an impeller having a "steep" characteristic is desirable. The head of such an impeller at "shut off" might be about 130 ft. which would cause the curve to slant more sharply downward from "shut off" to "wide open." At the point where the angle of inclination of the curve increases, there will be less variation in capacity for any change in head.

Efficiency Curve

Inspection of the efficiency curve, together with the head curve, will show us, almost at a glance, the head for any given capacity and the efficiency under the conditions in question. This curve starts at zero, rises to a maximum, and drops again as the capacity of the pump increases or as the head decreases. At "shut off" no water is delivered; at "wide open" no head is generated, and if it were possible to obtain zero head, the efficiency would again go down to zero.

Referring to Fig. 1, it will be seen that the efficiency curve is a flat-topped curve—it does not rise to a sharp peak but is nearly horizontal. This is an excellent indication and a desirable characteristic since it shows that the pump is capable of being operated over a wide range of capacity with high and nearly uniform efficiency. For instance, this particular pump has an efficiency of 60 per cent or over the capacities of from 1000 g.p.m. to 2400 g.p.m., a range of 1400 g.p.m.

The quick rise as the capacity increases from zero to 1000 g.p.m. is another desirable feature of this pump,

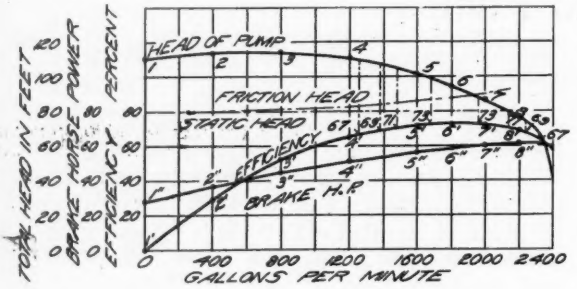


FIG. 1. CHARACTERISTICS OF A CENTRIFUGAL PUMP AT CONSTANT SPEED

but is possible only with the type of head curve shown. The efficiency at low capacities with a "steep" head curve would be considerably lower.

Brake Horsepower Curve

The power required under all conditions at a speed of 1420 r.p.m. is shown by this curve. It starts at 28 hp. which is the power required at "shut off," and after reaching its highest value when the delivery is 2200 g.p.m., falls off slightly. At 2300 g.p.m., 61 b.hp. is required. Should the head be reduced in order to obtain a greater capacity, the brake horsepower would decrease. His is termed a "non-overload" type of characteristic because it is impossible for the pump to consume over 61 b.hp. regardless of conditions as long as a constant speed is maintained.

The peak of the power curve is almost coincident with the peak of the efficiency curve. The motor and the pump can therefore operate, each at its maximum efficiency, and in case of a broken discharge pipe the motor cannot be damaged by resulting overload. The motor, however, must be selected to accommodate the full rated capacity of pump on which it is to be used, not merely the normal load under which it is to operate.

The term "non-overload" is entirely relative, and should not be taken too broadly. The percentage of overload is usually calculated with reference to the full rated capacity of the driving motor. Consider a pump sold for 1000 g.p.m. capacity; 48.3 hp. is required. If the power curve did not rise above 53 hp., a 48-hp. motor could be used; however, since the power curve goes up to about 61 hp., a 60-hp. motor must be installed, as a 48-hp. would be subjected to an overload of 26 per cent if the head was reduced.

The pump for which the accompanying curves were plotted has non-overload power characteristics for capacities from 1600 g.p.m. to 2200 g.p.m. only. For low capacities, the pump has an overloading power curve which must be taken into account.

As a general rule, when selecting a pump, care should be taken not to select a pump for a capacity which is materially less than the capacity at which maximum efficiency occurs—in this case, 1800 g.p.m.

Testing

Every purchaser of a centrifugal pump should subject it to some kind of a test to determine whether the guarantees of the manufacturer have been fulfilled, and to determine the characteristics. After the machine has been installed and in operation, occasional tests should be run to determine whether the pump is maintaining its rated efficiency. While these are not the only reasons for conducting tests on centrifugal pumps, they are the only ones the purchaser of a pump will be required to make.

Manufacturers of pumps usually have testing laboratories, or at least facilities for testing in their own plants and test every pump before shipping. If desired, they supply the purchaser with an official report of the test. There have been cases, however, where the makers, knowing the purchaser to be without facilities for testing, have made reckless guarantees when their actual tests had proved the apparatus to be deficient. In any event, it is desirable to test the pump after it is installed if it is feasible to do so.

The method of testing is as follows:

The pump to be tested is directly connected to a suitable electric motor of known efficiency with a voltmeter and ammeter connected into its circuit. A suction pipe fitted with a foot valve is connected to the suction side of the pump, and a discharge pipe, connected to a manifold containing calibrated nozzles, is connected to the discharge side. A pressure gage in the discharge line indicates the head in feet or in pounds pressure. The head on the nozzles is indicated by means of a mercury gage, while a similar mercury gage in the suction line measures the suction lift. The pressure and capacity can be varied by means of a gate valve in the discharge line.

After priming and starting, the speed of the pump is held constant throughout the test. As an example, suppose we take a pump and run it at a speed of 1700 r.p.m. Opening the discharge valve, we take the first reading and find that the suction lift is 4 ft. while the pressure gage shows a discharge head of 76 ft. If the suction and discharge pipes are of the same size, the two velocity heads are equal and cancel each other. Under circumstances where the suction and discharge pipes are of different sizes, however, this item should be taken into consideration. Assuming different sizes of suction and discharge pipe in this example and making suitable corrections, we find that the total net head is about 82 ft.

Inspecting the nozzle gage, we find a pressure of 41

in. of mercury and from a table listing various nozzle pressures with the corresponding delivery in gallons per minute, we find that 41 in. is equivalent to 512 g.p.m. Substituting these values in the formula for water horsepower

$$\text{Water hp.} = \frac{\text{g.p.m.} \times \text{head}}{3960}$$

$$\frac{512 \times 82}{3960} = 10.6 \text{ water hp.}$$

To obtain the brake horsepower, we refer to our voltmeter and ammeter readings which were recorded simultaneously with the other readings. At 512 g.p.m. and an 82-ft. head, the voltage was 232 while the amperage was 67. At this point, the efficiency of the motor was known to be 85 per cent.

Substituting these readings in the following formula, the brake horsepower is obtained:

$$\text{Brake hp.} = \frac{\text{E I} \times \text{Efficiency of motor}}{746}$$

$$\frac{232 \times 67 \times 85}{746} = 17.7 \text{ b.hp.}$$

The formula giving the efficiency is as follows:

$$\text{Present efficiency} = \frac{\text{Water hp.}}{\text{Brake hp.}}$$

Therefore the efficiency in this case is

$$\frac{10.6}{17.7} = 60 \text{ per cent}$$

This completes one set of readings. The discharge is then slightly closed and another set taken. This process is repeated until finally the gate valve is entirely closed and no water is flowing. These readings are then all carefully plotted and the characteristic curves drawn.

Notes in Regard to Testing

In the foregoing description of a centrifugal pump test, it was stated that a calibrated nozzle was employed for measuring the rate of discharge; however, in case such a nozzle is not available, other means of measuring the discharge rate may be used. Sometimes the amount of water that is discharged in a known interval of time is measured or weighed and the rate so obtained. A Venturi meter or a Pitot tube may be employed and in cases where an excessively large capacity is to be dealt with, a weir is used.

To measure the volume of, or weigh the water discharged in a certain time interval is feasible for small capacities only, except in exceptional circumstances where water is delivered to a large reservoir.

The speed of the motor is most easily determined by means of a reliable and sensitive tachometer. This will not only indicate the speed at a given instant, but will show if the speed is varying. A very good device for measuring speed has been found to be a magneto and a voltmeter. The magneto is belted or geared to the pump shaft and connected to the voltmeter. By calibrating the voltmeter scale directly in revolutions per minute, it will afterwards serve nicely as a tachometer.

In plotting curves, it should be kept in mind that while any single point may be in error, all of them should follow a definite law, unless some factor is introduced which causes an abrupt change from one law to another. Smooth curves should therefore be drawn rather than to attempt to draw curves through the points taken from the test data.

Methods of Drive

The centrifugal pump can be driven by any of the following methods:

Belt or direct connected to { Gas engine / Electric motor / Steam engine }

Direct connected or through reduction gears to steam turbine.

As a general arrangement, a belt drive is better adapted to relatively small centrifugal pumps, than to large units. Belts, at best, are troublesome and are to be avoided wherever practicable. However, when this form of drive is employed, the belt centers should be kept a reasonable distance apart, especially in cases where there is considerable difference in the size of the pulleys. The tight side of the belt should be underneath, as this increases the arc of contact and enables more power to be transmitted. A belted pump should always be designed for minimum speeds in order to maintain low belt

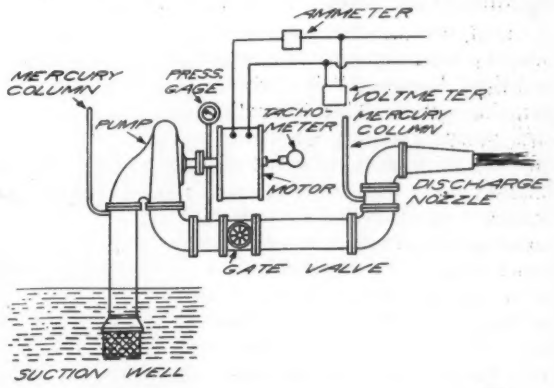


FIG. 2. SCHEME OF CONNECTIONS USED IN TESTING

speeds. Except in special cases, the belt speeds should not exceed 4500 ft. per min.

The direct-connected motor drive is by far one of the most common and satisfactory forms of drive for centrifugal pumps. It requires a minimum amount of floor space, has a high transmission efficiency and needs little attention. It can accommodate itself to almost any condition, owing to the fact that motors of practically any speed can be secured. By the use of a variable speed motor a number of pumping conditions can be satisfied in the same unit.

Furthermore, the centrifugal pump, being a relatively high-speed machine, is well suited to the high-speed electric motor. Since high-speed motors are cheaper than low-speed motors, there is a consequent saving in the initial cost.

To allow for slight variations in alinement, a flexible coupling should always be inserted between the driving motor and the pump. This will insure cool bearings, reduce vibration, improve the running qualities.

Although satisfactory and economical, the application of direct-connected steam or gas engine drive to centrifugal pumps is somewhat limited, due to the rela-

tively low speed of ordinary reciprocating machinery. It is confined mostly to low speeds where low and medium heads are encountered.

Steam turbine drive for the centrifugal pump combines the maximum efficiency of power transmission, with simplicity, compactness, reliability and small weight. It is rapidly gaining in popularity in locations where steam is available, especially in power plants and on shipboard.

Both being high-speed machines, the steam turbine and the centrifugal pump are admirably suited to each other, and since the progress made in the design and development of small steam turbines, this form of drive has become very economical. The speed of a turbine is even more easily regulated than the speed of an electric motor, and being equipped with nozzles which can be cut in or out as desired, is efficient under partial loads. Maximum efficiency can be obtained at all times. The turbine can, furthermore, be equipped with a special governor which is controlled by the discharge pressure of the pump. When the pressure falls, the governor will cause the speed of the turbine to increase; when the pressure rises, the speed of the turbine decreases. The pressure produced by the pump is thus maintained constant regardless of the amount of water delivered.

Small turbines are usually direct-connected to the pump by means of a flexible coupling. To meet certain conditions, however, it is advisable to interpose a set of reduction gears. This is particularly the case where large pumps handling low heads are to be driven. In this case, the economical speed of the pump may be considerably lower than the economical speed of the turbine. Therefore, in order that each machine may operate at its most economical speed, a set of reduction gears is connected between them. These gear sets are entirely enclosed in dust-proof casings, containing independent bearings and lubricating systems and are highly efficient. The loss in power incurred by their use is sometimes less than two per cent, and is more than offset by the gain in economy obtained by the use of the turbine.

Much of the data used in the preparation of the foregoing article, which is the second of two articles dealing with centrifugal pumps, was taken, by special permission, from the confidential sales data sheets of the Goulds Manufacturing Co., to whom credit is hereby given.

A Big Idea

YOU are concerned about your rights.

And you ought to be.

The fact that you are concerned about your rights should lead you to consider your duties.

The faithful performance of your duties to society and the state constitutes your claim to rights.

More than that it is the means by which your rights may be preserved from infringement.

The normal man's right to live depends upon his willingness to engage in useful service to the community.

His right to greater freedom depends upon the intelligent and socially responsible use of the liberty he now enjoys.

If we are asleep and do not recognize the menace to our rights and liberties which exists in the activities of those organizations seeking to destroy our government, we are forfeiting our rights to those liberties, and are likely to lose them. Leading the attack are the Union of Russian Workers, the Bolsheviks, the Communist Party, the Communist Labor Party, the I. W. W. and others. Their effort is to spread sedition and disloyalty among the people of the country, both by newspapers and circulars, and by personal appeal in meetings and in the shops.

They are untiring in their work, and unless loyal, earnest effort is made to counteract their propaganda, many are likely to be influenced and misled by them.

United effort is more effective than scattered and to get concerted action United Americans has been organized throughout the country to fight by every lawful means those who try by threat or by violence to overthrow our government or break down the safeguards which protect the rights of persons and property under our flag.

United Americans does not claim that America is perfect; that there are no wrongs to be made right; no injustice to be removed; no reasons for people to find fault. But United Americans believes that there is no country where the people have a better chance to make life what it ought to be if they will use their brains, their labor and their opportunities wisely. It sympathizes with those who are bearing burdens and suffering hardships, and it wants to help make these burdens lighter and these hardships less.

United Americans is friendly to those of foreign birth or blood. It is eager to help them to understand America and American ways, and to make it easier for them to join with all who live beneath the Stars and Stripes in working for real freedom, justice, a better chance and a greater prosperity, under the safety of the law and the blessing of peace.

It knows no political parties, no religions, race or class distinctions. It asks only one question: "Do you support the Constitution of the United States of America?" It has one declaration of faith. "We believe in the Ten Commandments, the Golden Rule and the Constitution of the United States."

Under this, working through our free institutions, discussion, assembly, the ballot, making and amending of laws by elected representatives of the people—wrongs and evils can be righted, and such changes made as are needed to secure freedom, justice and happiness for a united people.

For these two purposes—to correct wrongs by lawful means—and to fight disloyalty and revolution, the organization has been formed and will work.

State organizations are formed and a national program is being outlined.

There is a real danger, even though it is not appearing openly. Underground methods are being employed to spread sedition; advantage is being taken of restlessness and dissatisfaction to increase industrial disturbances. It is time for us all to awake.

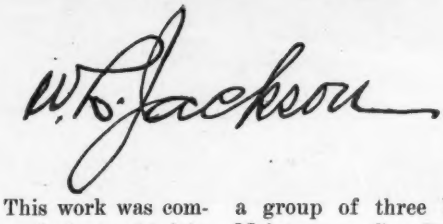
Membership in United Americans is an expression of peace time loyalty and patriotism akin to that shown during the war, and is a badge of honor. The headquarters for Illinois are at 108 South La Salle street, Chicago, from which full details may be obtained. Are you awake?

WALTER L. JACKSON

BEGAN AS A FIREMAN AT THE AGE OF 15. THEN ACQUIRED WIDE EXPERIENCE IN OFFICE BUILDING POWER PLANTS. BY WALTER PAINTER

THE GENIAL chap who today is manager of the power and equipment division of the N. K. Fairbank Soap Co. at Chicago, attends to the power generation and all mechanical equipment involved in the operation of five large factories. He is another interesting specimen of the technically-minded youth who, after a prolonged course in the dear old university of hard knocks, handles a variety of responsibilities with ease. He is Walter L. Jackson.

Walter left the little school up at Portage City, Wisconsin, at the age of 15 to fire a small boiler at the town foundry. A year later, he left home in order to assume the dual obligations of fireman and engineer in a small factory making wagons and farm implements. Owing to his mother's illness, he returned home several years later and worked as a wagon painter. While experimenting with a new paint, Walter became badly poisoned and spent 18 months convalescing at a hospital, and then worked there for a year as fireman and engineer at the rate of $20 a month with board, washing and medical treatment in order to pay off his indebtedness.



Then young Jackson took a job with the Thomson-Houston Co. as lineman and installed an arc-lighting machine and lighting service in Hudson, Wisconsin. This work was completed in six months and he then worked at odd jobs such as water pipe extension, wiring homes for light, installing a fool-proof alarm in the city reservoir and overhauling an old Silsby Steamer pump.

In the spring of 1893, Jackson came to Chicago and became operating foreman in the electrical department of the World's Fair. He was in charge of 138 electrical generators used for producing current for the exposition buildings and grounds.

In the fall of 1894, he obtained work at $1.50 a day as inspector on an underground conduit system for electric feeder lines and had the elevating task of watching a gang of Italians mix concrete. During his odd moments, he studied elementary surveying and at the end of three weeks was promoted to be assistant to the engineer in charge and found his salary boosted to $5 a day. Being told that he would receive pay for Sundays whether or not he worked, the joker soon came out in the fact that profile drawings had to be made showing the conduit as installed and the locations of all manholes and cross-over gas, water, telephone and fire alarm lines. Although this work kept him busy every Sunday, he frequently found an opportunity to study the large power plant being erected by the West Division Street Railway to deliver current through this conduit system, When the work was finished, Jackson became connected with the street railway as foreman in charge of the erection of poles, the stringing of trolley and feeder lines.

After spending a year on the sideline because of rheumatism, Jackson was made foreman of the rail and structural bonding work being carried on by the Lake Street Elevated Railroad. After this was completed, he was made the fireman, engineer, electrician and steam fitter for a Chicago office building newly erected. Three years later, he was appointed chief engineer for a group of three buildings operated by the Illinois Maintenance Co. It was here that he became acquainted with William L. Abbott, from whom he received much helpful advice and friendly support.

Later, Mr. Jackson was made chief engineer of the First National Bank Building, which, at that time, was the largest office building, in cubical content, in the United States. His supervision of the installation of this plant included the steam heating system, the electrical wiring and all plumbing. One of the features introduced in this building was the installation of wattmeters on all circuits furnishing light to tenants. After operating this plant for 16 yr. Mr. Jackson

was given a leave of absence to work for Uncle Sam at Nitro, West Virginia, as assistant chief mechanical engineer at the large powder making plant located there. With the end of the war in sight, he accepted the position with the N. K. Fairbank Co. which he now fills so ably.

Mr. Jackson is not alone an engineer by profession, but equally so by character. He has diligently sought after the laws of physics, chemistry, psychology and other natural and applied sciences which are used in engineering, and built upon the laws thus revealed foundations for his working machinery. He never "kids" himself into the belief that his plant is doing better than it is. This one characteristic is responsible, probably above all others, for the nation wide reputation Mr. Jackson enjoys as a specialist on operating records for office building power plants.

In the First National Bank Building, he developed a system of records that were complete. Any change in equipment, program of operation, fuel, quality of oil, installation of a new instrument and many other influential conditions in the plant left a definite trace in his records within 24 hr. So it happens that many new devices and instruments, while still in the experimental stage commercially have been tried out to success or failure in his plant. "Let me show you how it works over in Walter Jackson's plant," is a common sales argument among representatives of power plant specialists in Chicago, and there are few better that they could advance.

"Hew to the line, let the chips fall where they may," may not be Mr. Jackson's motto, but it is truly descriptive of his character.

The Solid Injection Type of Oil Engine

A Brief History and Description of a New Type of Oil Engine

TO SATISFY conditions peculiar to isolated power plant practice or other similar installations demanding great reliability under constant and practically full load, or widely fluctuating load conditions, an oil engine should possess the following qualities: simplicity in construction and operation, high efficiency, durability and reliability, and the ability to operate on a wide range of fuels.

To meet the need for an oil engine for use in small plants requiring up to 125 hp., the Hornsby-Akroyd engine was introduced in 1893. This engine, which was the pioneer of all the hot-bulb or "surface ignition" engines, was an English product. It was a four-stroke-cycle engine with a vaporizer or uncooled bulb included in the cylinder head. The oil was injected into the bulb and owing to the intense heat contained in the walls of the bulb, was vaporized. At the end of the compression stroke, the heat of the bulb, increased by the heat caused by compression in the cylinder, was high enough to ignite the fuel. The engine was an explosion or constant-volume engine and followed the Otto cycle in its action.

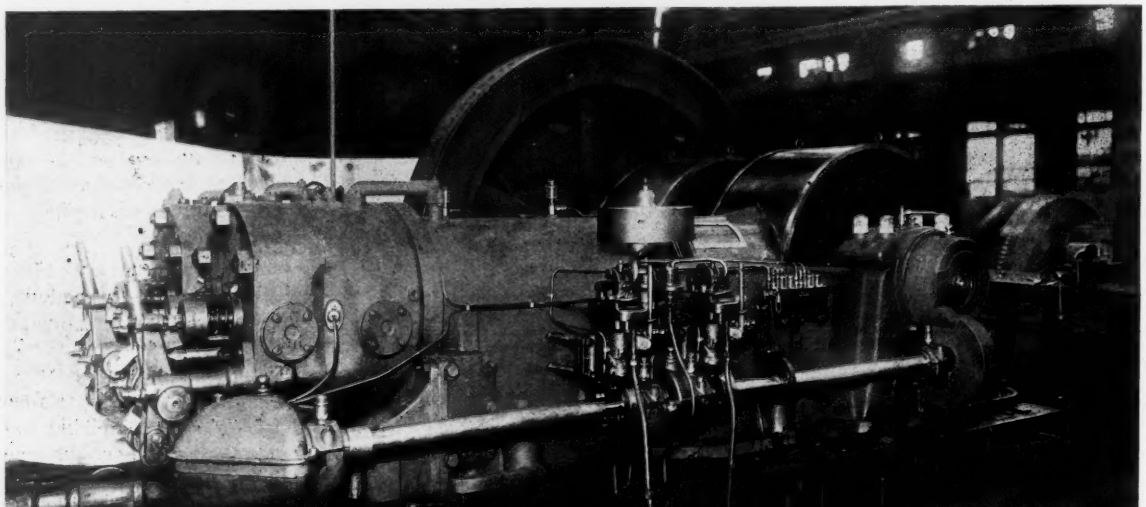


FIG. 1. TWIN CYLINDER TYPE SOLID INJECTION OIL ENGINE

The many admirable features of this type of prime mover soon won for it a position of great popularity and due to the subsequent improvements made upon it, it soon came into general favor in this country. It employed a low compression of about 50 lb. per sq. in., although later modifications of this engine have the compression as high as 140 lb. per sq. in. The variation in compression is dependent on the time of depositing the fuel charge in the vaporizer.

The advent of an unlimited supply of cheap, heavy,

crude oils augmented the demand for a small engine of the type described which would be suitable for operation on crude oils as well as the lighter oils. Succeeding developments in these engines during the following years evidenced such remarkable results in the way of dependability and cheap operative costs that it was only natural that there should follow a demand for an engine of similar design adapted to larger horsepowers. This resulted in the recent development of the solid injection type of oil engine.

In the smaller units simplicity of design and freedom from all needless complications are of paramount importance. Owing to the elimination of the air compressor and attendant mechanism, the simplicity of the solid-injection type of oil engine is apparent while the method used for injecting the fuel gives it a high thermal efficiency. A test on a single-cylinder, horizontal type, solid-injection engine resulted in a fuel economy of 0.40 lb. of oil per brake horsepower with the engine operating at full load.

This engine, as shown in Fig. 1, is a single acting, horizontal, four-stroke-cycle engine with a medium compression of about 330 lb. per sq. in. and a maximum combustion pressure of 450 to 500 lb. All parts of the

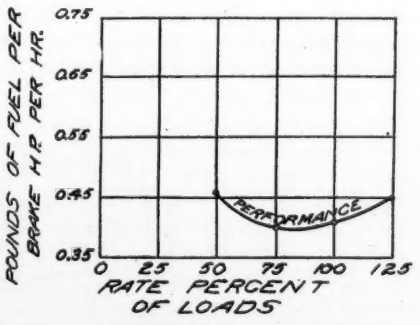


FIG. 2. FUEL CONSUMPTION CURVE OF SI TYPE ENGINE

engine are on a level with the operator's eye, are easily reached and controlled, and can be quickly disassembled for inspection or repair. It is neat in appearance and has a minimum of moving parts. Special attention has been given to the arrangement of the necessary piping which is all attached in such a manner as not to be conspicuous.

The governor is of the centrifugal type, operated by worm gears from the layshaft. The quantity of oil passing to the spray valve is controlled by an extremely simple arrangement. The governor arm acts on the discharge valve of the oil pump through a simple linkage, so arranged that the quantity of fuel permitted to pass to the spray valve is readily controlled, thus regulating the engine speed. All the oil that the governor thus bypasses is fed back to the engine standpipe.

The fuel pump is mounted on the governor bracket and is operated by a cam on the layshaft.

The cycle of operation of this engine is as follows:

Suction stroke: The intake valve is opened mechanically and the piston moved forward on the suction stroke drawing in a full charge of pure air.

Compression stroke: The intake valve is closed. The piston returns compressing the air from the cylinder into the combustion chamber to a pressure of approximately 330 lb. per sq. in. On account of the perfect system of fuel injection, this pressure is ample to cause ignition.

Working stroke: The oil is injected slightly in advance of inner dead center. Combustion at constant volume occurs when the pressure rises from 330 to approximately 500 lb. per sq. in. The piston starts out on the working stroke.

Exhaust stroke: Near the end of the working stroke the exhaust valve is mechanically opened. The pressure drops and the piston returns, expelling the burnt charge.

Starting and stopping of the engine is accomplished by the admission of air from storage tanks furnished with the engine. To start it, the crank is placed in starting position and the control lever is shifted to the starting notch. A cam on the camshaft then successively opens and closes the starting valve, admitting air under a pressure of about 200 lb. at the proper time intervals. When the engine picks up speed the control lever is shifted to the running position, which automatically cuts off the starting air.

The engine is free from hot caps, uncooled castings, hot surfaces or ignition plugs, a feature which is not only of great advantage in eliminating over-heating at high loads or excessive cooling at light loads, but also permits a full charge of air to be drawn in. This is one of the reasons for the high power obtainable from a given piston displacement.

The curve shown in Fig. 2 was drawn from data supplied by the De Lavergne Machine Co. and taken from a test of the solid-injection type of engine, using Navy standard fuel oil.

British Union Demands Professional Recognition

IN "The Surveyor," London, is an article relative to the first national convention of British Architects' and Surveyors' Assistants' Union. The convention was held in Sheffield, and was attended by delegates from some 13 cities in England and Scotland.

Some of the matters acted upon were:

Abolishment of present system of articles and apprenticeship.

A minimum salary scale.

Establishment of an employment bureau.

Condemnation of the practice of local authorities in employing non-professional men to do professional work.

Condemnation of the very general practice of designating qualified professional men as "assistants" and "draftsmen" instead of "assistant architects" or "assistant surveyors."

WHEN A slight change in the speed of a shunt or compound-wound motor is desired, it can be obtained by shifting the brushes; moving the brushes forward will decrease the speed, and vice versa. If the brushes are shifted too far, poor commutation will most likely result; any greater variation in speed should be accomplished by variable resistance in the shunt field. In an emergency, a quick reversal of the direction of rotation can be accomplished by shifting the brushes, preferably forward, until the positive brushes are in the position formerly occupied by the negative brushes.

New Conveyor-Feed Type of Stoker*

PARTICULARS REGARDING A NEW TYPE OF CHAIN GRATE STOKER ON WHICH EASTERN BITUMINOUS COAL MAY BE SUCCESSFULLY BURNED

IN burning eastern bituminous fuels on chain grate stokers, the chief difficulty is due to the fact that they cake or coalesce under the arch, and thus prevent the entrance of air through the fuel bed and check combustion. In view of overcoming this difficulty experimenting has during the past 2 yr. been done on a new type of forced-draft stoker which has been developed to burn eastern bituminous coals with success.

This stoker, described in a paper presented at the spring meeting of the American Society of Mechanical Engineers by L. R. Stowe, of the Laclede-Christy Clay Products Co., employs the conveyor method of feeding, i. e., it uses progressively moving chain-grate conveying elements to feed the coal through the furnace and to discharge the refuse to the ashpit.

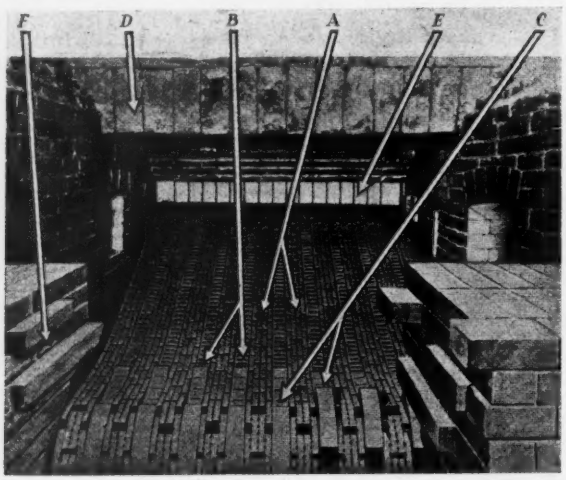


FIG. 1. VIEW OF GRATE SURFACE AND FURNACE

The chain-grate principle has advantages which are attractive to the stoker designer, and as a result of this and of the fact that underfeeds have quite thoroughly demonstrated the great advantages of mechanical draft, many builders are now experimenting on and developing various forms of forced draft conveyor-feed stokers.

It has been established for many years that when burning caking fuels on chain grates with natural draft, nearly every requirement of a successful stoker is lacking. It will be observed, that one of the characteristics of the conveyor feed is, that the fuel bed is undisturbed during the so-called coking period or, more properly speaking, the period of destructive distillation. The coal cakes almost immediately upon entering the furnace, high rates of combustion cannot be secured, the combustible content of the ash is high, the admission of air is not properly graduated to the requirements of the various stages of combustion, and maintenance of the links is excessive.

The caking property of eastern coal is well known. In endeavoring to burn Pocahontas and similar coals, it is observed that tarry oils flow through the fuel bed as a result of the application of heat at moderate temperatures, and that the coal under the arch is caked by these tarry oils.

The most natural means of remedying this situation is to break up the caked fuel bed mechanically and this is the course almost invariably taken up by the inventor. The stoker described herein, however, does not use this method and disproves the prevalent idea that "A mechanical agitation of the fuel bed, for the purpose of breaking up the cake, is necessary or advisable when burning eastern coals."

CAUSES OF CAKING TENDENCY

WHILE ALL bituminous coals have a resinous content, its adhesive or binding property is lacking in the western or free-burning coals. It seems that the higher the oxygen content of the coal, the less pronounced will be the primary caking tendency. Analyses show that eastern coals contain less than half as much oxygen as do the western coals of non-caking characteristics. It is furthermore well known that eastern caking coals lose their caking properties by weathering, and it has been determined that weathering causes coal to absorb oxygen.

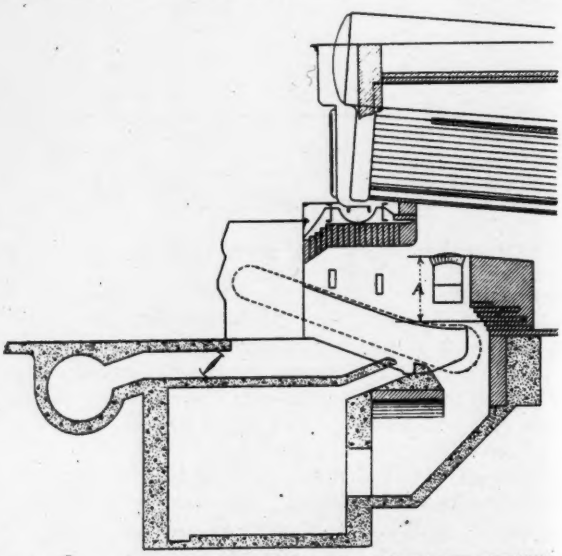


FIG. 2. SECTIONAL ELEVATION OF BOILER AND STOKER

The absorption of oxygen can be accelerated and be made to take place in the furnace by producing very high temperatures and accompanying these with a plentiful supply of air. The adhesive qualities of the resinous material referred to above, are apparently destroyed by the absorption of oxygen, and hence, the caking of the fuel bed is prevented.

The extremely high ignition temperatures obtained with the new stoker together with the considerable quantity of air forced through the fuel bed at these temperatures provide for the absorption of sufficient oxygen to destroy the initial caking tendency. It is also reasonable to suppose that at the same time these high temperatures cause quite a different procedure during de-

*Abstract of paper presented before American Society of Mechanical Engineers.

structive distillation than that which obtains with lower temperatures. The entire absence of cake formation changes completely the nature of the fire under the arch and also has a marked effect upon the last half of the fire.

Description of New Stoker

The grate surface of the stoker is shown in Fig. 1. The general incline is 20 deg. The arrows indicated by A, point to narrow chain grate or conveying elements, about 4 in. wide and placed on 7-in. centers. In the intervening 3-in. spaces are placed stationary tuyeres indicated by arrows at B. At the lower end of the grate surface the tuyeres, B, terminate in short pivoted bars, C, which are made automatically to rise above, then drop below, the surface of the conveyor chains. This action takes place slowly. E is a feed grate, adjustable to give various thicknesses of fire exactly as on a chain grate. Partly overhanging the vibrating bars, C, is the bridge wall, F, shown cut away in the center. An ignition arch is shown at D. This latter conforms to chain-grate practice except that with the greater incline of the grate the arch is farther away from the fire. Figure 2 shows a cross-sectional side elevation of the stoker and boiler.

A great expanse of bridge wall extending from a point horizontal with the arch to or nearly to the fuel bed is known to be of the utmost value in directing heat on the incoming fuel. This is the surface indicated by A in Fig. 2. The steep incline of the stoker in question permits this dimension A to be greatly extended over that possible with the ordinary chain grate. The form of arch, was also taken from chain-grate practice and its design and location has, of course, contributed its part toward the building up of the high fuel-bed and ignition temperatures that play so important a part in preventing the caking and ultimate coking of the fuel.

In regard to the air supply, which has been shown to be a requirement for coke prevention, the greatest percentage of the total supply is supplied through that part of the fuel bed under the arch. This air supply, coupled with the very high fuel-bed temperatures obtained, destroys any tendency toward the formation of coke and has made it possible to burn eastern coal with considerable success.

Operation

The stoker is almost entirely automatic in operation, the only condition which requires more than a minimum amount of the operator's attention is the formation of clinker on the side walls. While this clinker formation is no more serious than with the ordinary chain grate, experiments are under way still further to minimize the evil. Due to the lower ash content with its higher fusing point, eastern coals require less side-wall slicing than those from the middle west.

Air Supply

The air pressure in the wind box is uniform under the entire grate, but the air openings in the tuyeres are such that the greatest amount of air is supplied to that part of the bed where the early stage of combustion takes place. Investigation has determined that the greatest quantity of combustible particles are liberated in the zone of destructive distillation, hence, the greatest quantity of air must be supplied at that point. The tuyere construction is well suited to such a requirement and since the tuyeres are cast in interchangeable sections containing varying percentages of air openings, any gradation in air spaces between the two extremes noted in the tabulation may be made.

Low Combustible in the Ash

High ignition temperatures in a furnace are important in the reduction of combustible matter in the ash, with the conveyor-feed type of stoker. In the initial stages, the coal burns from the top down; while during the latter stages, the burning is reversed, the bottom of the fuel bed, where the air is richest in oxygen, being most active. The higher the ignition temperatures, the quicker this reversal is effected and if an early burning from the bottom up is established, the combustible in the ash will be materially decreased. The high ignition temperatures of this stoker have unquestionably aided in reducing the combustible of the ash to a satisfactory amount.

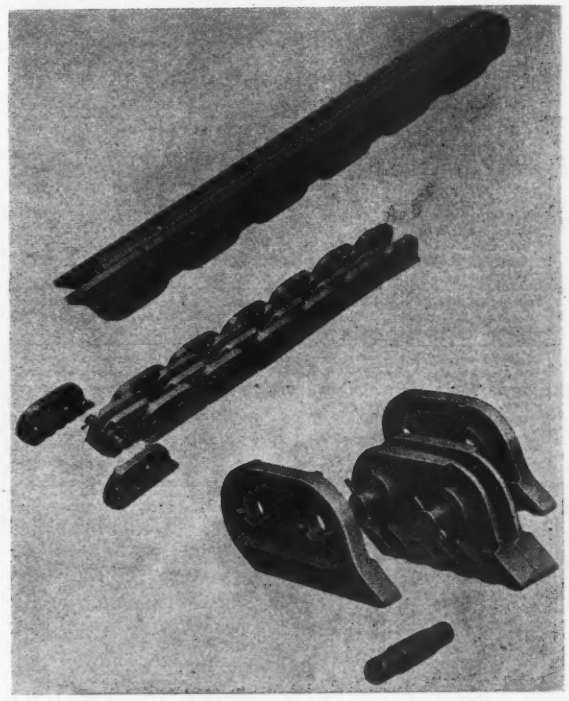


Fig. 3. Details of the conveying elements marked A in Fig. 1

The thickening of the fuel bed near the discharge end of the grate is brought about by the retarding mechanism previously described and shown in Fig. 1. When elevated, the short pivoted bars C raise the nearly spent fuel above the chains, thus holding it back, and when depressed, permit the conveyor elements to carry the ash out of the furnace. The relative duration of these two influences can be controlled by the operator and the fuel bed near the discharge end of the furnace can be held back and thickened to any desired depth. Full wind-box pressure at this part of the grate forces high velocity air jets into the thickened bed and hence is particularly advantageous in burning out the remaining particles of combustible.

High Rates of Burning

It is quite apparent from the foregoing reference to mechanical draft that high rates of burning are attainable with this new type of stoker. Its intensely-active bed assists materially in securing higher rates of fuel consumption. High CO_2 results quite naturally from

PRESENT-DAY REQUIREMENTS OF AN AUTOMATIC STOKER COMPARED WITH THE PERFORMANCE OF CHAIN GRATE AND CONVEYOR-FEED STOKERS, EACH USING EASTERN COALS

	Requirements of the Present-Day Stoker	Results Obtained with Eastern Coals: With Chain Grates	Results Obtained with Eastern Coals: With Conveyor-Feed Stoker Described
1	It should completely burn all combustible that arises from the grate, and perform this task under the great handicap of using no more air than is required.	Thin fires spotted with upstanding coke result in excess air and low CO_2 due to the fact that the air supply is not graduated down to a minimum at the rear of the stoker and to influences attending the coking of the fuel bed.	Graduation of air supply and thickening of fire near point of ash discharge and the prevention of coke assure a consistent 10 to 12 per cent CO_2 content with positive assurance of an intimate mixture of air with combustible gas.
2	It should bring about low combustible in the ash.	Combustible in the ash from 30 to 50 per cent.	Combustible in the ash from 16 to 24 per cent.
3	It should burn coal at high rates of burning — not only to obtain high capacities but to widen the range of economical rates of burning as well, in order that great flexibility may be assured.	Rates of burning from 25 to 35 lb. of coal per sq. ft. of grate surface per hour.	Rates of burning up to 60 lb. of coal per sq. ft. of grate surface per hour.
4	It should be as nearly wholly automatic in operation as possible.	Successful in the matter of automatic operation.	Successful in the matter of automatic operation.
5	It should not entail unreasonable expense in the upkeep of the grate surface or of the furnace brickwork.	No unusual maintenance cost for furnace brickwork, but a very high one for grate links.	Use of mechanical draft imposes a more severe condition for furnace brickwork, requiring a higher grade of refractories, but maintenance of ironwork is not excessive — in fact, may be considered quite satisfactory.

(a) the proper air distribution described; (b) the thicker fuel bed particularly at the discharge end; (c) the higher temperatures that cause increased chemical activity; and (d) the impinging jet action on the fuel particles produced by small air spaces and forced draft.

Low Maintenance

The deep fuel bed and a thick layer of refuse effectively protects the grate from the heat of the fur-

AIR SPACE DISTRIBUTION ADOPTED FOR CONVEYOR-FEED STOKER

Air space in each element at feeding end		Air space in each element at discharge end	
Conveying elements	8 per cent	Conveying elements	8 per cent
Tuyere elements	22 per cent	Tuyere elements	2 per cent
8 per cent of 60 per cent	= 4.8 per cent	8 per cent of 60 per cent	= 4.8 per cent
22 per cent of 40 per cent	= 8.8 per cent	2 per cent of 40 per cent	= 0.8 per cent
Total air space	= 13.6 per cent	Total air space	= 5.6 per cent

Conveyor elements, about 60 per cent of total grate surface
Tuyere elements, about 40 per cent of total grate surface

nace. In addition, full advantage has been taken of the cooling action on the links of the incoming air.

While high rates of burning and high temperatures, of course, subject the brickwork to very severe service, the wind-box pressures are low (less than 2 in. of water) and this combined with the large number of uniformly distributed small air openings, causes the blow-pipe action to disappear quite near the surface of the fuel bed, thus minimizing to some degree the brickwork deterioration.

The problem of more severe furnace conditions has thus far been met by employing refractories of a higher grade.

How Efficient Is Your Packing?

By W. F. Schaphorst

Packing is one of the many things that cause a certain amount of trouble, especially when it must be removed, or when the shaft must be turned down smooth on account of scoring. Otherwise, however, it is seldom given a thought, and the same kind of packing is frequently used over and over again, often at a considerable money loss. It, therefore, occurs to the writer that engineers might be interested in a simple test that can easily be made to determine the friction of a given packing in order to compare it with the friction of any other. This test, of course, should be made on a new and unscored shaft.

Pack the stuffing box of a centrifugal pump, say, with packing No. 1, just tight enough so there is no leakage of water. Then disconnect from the motor or engine, and rig up a crank of some kind so that the shaft can be turned by hand. This crank must have a measured distance, in inches, from the center of the shaft to the point of application of the pull necessary to revolve the shaft. The direction of pull must always be at right angles with the crank arm. Rotate the shaft slowly, and by means of a pair of spring balances determine the pull required, as closely as possible, in pounds. Experiment with it until you are sure you have the correct number of pounds, and then make a note of it so as not to forget.

Then do the same thing with packing No. 2. Invariably one packing will create more friction than the other. The packing that creates the least friction, to be sure, is the most desirable. This test can, therefore, be continued time after time until the packing of minimum resistance is found.

Now subtract the minimum pull from the maximum, both of which should be in pounds; multiply by the length of the crank arm in inches, then by the number of revolutions made per minute by the pump, and divide the product by 63,100. The answer is the horsepower loss due to poor packing.

For example, let us say that the pull with packing No. 1 in place is 10 lb., and with packing No. 2 it is 4 lb. The difference, therefore, is 6 lb.

If the length of the crank arm is 12 in. and the revolutions per minute of the pump is 600 we will, therefore, have

$$\frac{6 \times 12 \times 600}{63{,}100} = 0.685 \text{ hp.}$$

To be continually losing this much power because of poor packing is quite an item. Perhaps you are losing more than this, perhaps not so much. At least, it is a test that is worth trying if you are dissatisfied with your present packing and wish to determine whether or not it will pay you to purchase a kind that is more expensive, but claimed to be much better. This can be fig-

ured on the basis of the cost of a horsepower per year. Thus if a horsepower per year costs you approximately $50, the cost of power lost in the foregoing example due to poor packing must be

$$\$50 \times 0.685 = \$34.30$$

It is plain, then, that a considerable money loss may lurk in your packing methods year in and year out. Buy the kind that seals in the water, gas, or steam effectively, and which presents the least friction drag.

Dynamiting Old Foundations

IF YOU have something you don't want and it is hard to get rid of, just put a stick of dynamite under it—no, on top—no, in—well, we'll not tell you just where to put the charge; but if you will do the job just right, you will break down the foundation, if that is what is in your way, and there is no more danger to it than handling high-voltage electric circuits. It is all in the "know how."

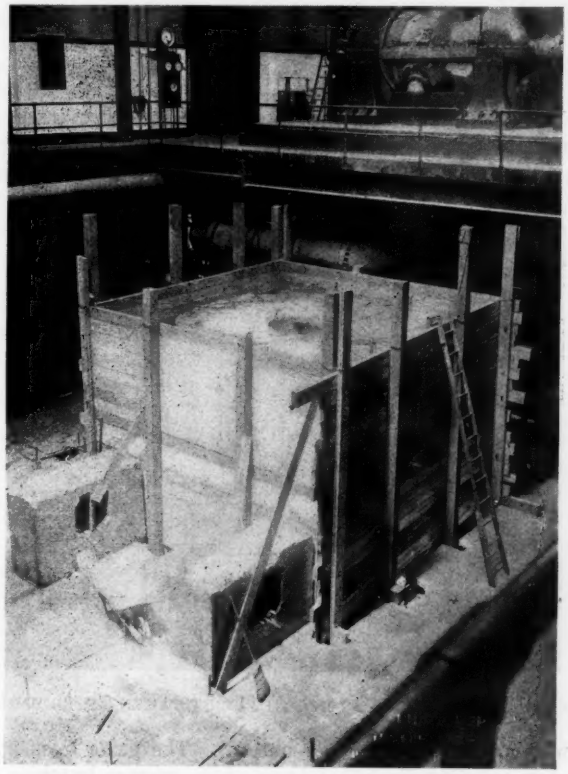


FIG. 1. TURBINE FOUNDATION AS PREPARED FOR DYNAMITING

Witness the accompanying illustrations of three stages in the process of removing a vertical turbine foundation in the Burlington station of the Public Service Electric Co. With the most approved method of drilling and chipping, a neater job could not have been done than was accomplished here. Not only has this kind of a job been done once, but many times has N. A. Carle, chief engineer of the company, employed dynamite for wrecking foundations almost regardless of the proximity to machinery which is kept in service even while the charge is being fired.

In this particular case, holes were drilled from the top well toward the bottom of the foundation; a shield was built up around the work to prevent the spreading of the large pieces and the flying of the small bits; the holes were charged with the proper amount of dynamite which was set off by an electric current. The largest chunks were of such size that they could be handled

FIG. 2. WRECKED FOUNDATION AFTER REMOVAL OF CASING

by the crane and the remaining debris was removed with wheelbarrows. No further breaking than that done by the explosive was necessary.

The principal secrets to the successful use of dynamite for such purposes are the amount to use, where to place it and how to seal the charges. The underlying laws are just as definite as those for electricity, but most of us do not know them and are not anxious to do any experimenting; in this case, particularly, it is wise

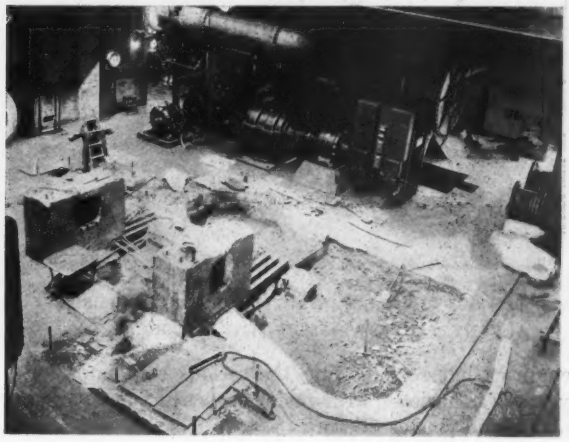
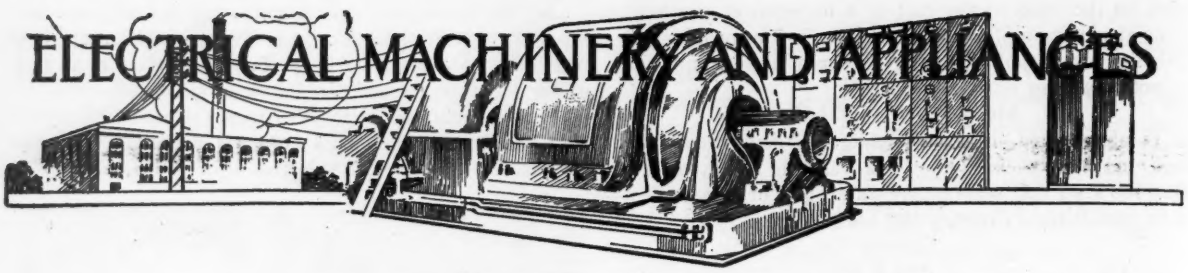


FIG. 3. PREPARATIONS FOR FOUNDATION FOR NEW UNIT

to learn from the experiences of others. Mr. Carle learned the art while engaged in mine work.

ACCORDING to scientists the ordinary flow of the river at Horse Shoe Falls, Niagara, is 275,000 cu. ft. per second, developing an unharnessed horsepower of approximately 5,000,000 or the power of 15,000,000 strong draft horses, each horse being confined to an 8-hr. day.—Sibley Journal of Engineering.



Industrial Illumination---III

PRACTICAL CONSIDERATIONS. BY VICTOR H. TODD

THERE IS perhaps no better way of demonstrating the principles involved in scientific industrial illumination, than to select a modern, well designed installation and reviewing each point from the theoretical and the actual viewpoints, determine why certain features were selected in preference to others, which from a casual consideration might appear preferable. As a typical example, let us select the new assembling department of a large electric manufacturing company used in the assembly of direct-current instruments. This room represents the last word in scientific illumination, its final design not being the exclusive design of any one engineer but representing the serious contemplation of years of experience with various types of lamps, arrangements and classes of work.

FIG. 11. ASSEMBLY DEPARTMENT OF MANUFACTURING COMPANY TAKEN AT NOON TIME OF BRIGHT DAY

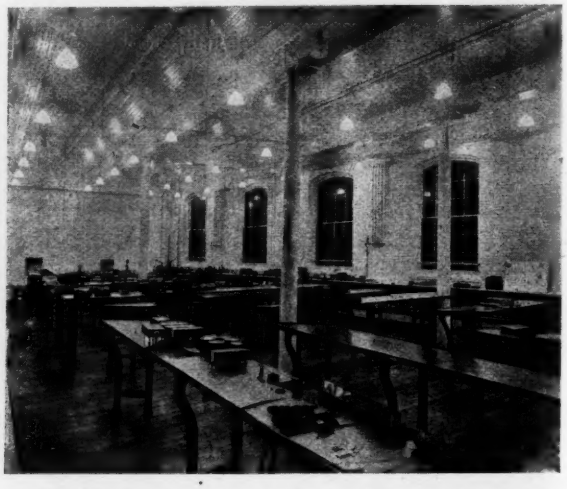


FIG. 12. SAME VIEW AS IN FIG. 11 BUT TAKEN AFTER DARK

In order to limit the discussion to figures easily grasped and comprehended, let us select an isolated section of the department which is 28 by 56 ft. with a ceiling 13 ft. high. The building is of brick construction, this room being located on the third floor; six windows on the side facing east, and three windows on the side facing south; the north wall is blank and the west wall has three large doors leading to the remainder of the factory. Figure 13 shows the floor plan and elevation of the east side.

As stated in previous articles, the main points for a preliminary consideration are as follows:

1. Class of work to be illuminated.
2. Desired illumination intensity.
3. Color of walls and ceilings.
4. Type of lamp desired.
5. Type of reflector.
6. Are proper supply circuits available?
7. What type of wiring and control?

CLASS OF WORK

BY EXAMINING a high-grade direct-current instrument of the D'Arsonval type, it will readily be appreciated that nothing but the best illumination will do, whether it be artificial or natural. The parts in many cases are much finer than those of the average watch and the assembly is just as accurate and precise, as not the least variation will be tolerated in these instruments, the parts being strictly interchangeable throughout.

INTENSITY DESIRED

TABLE II gives the intensities of illumination usually employed in various industrial operation, and it will be seen that it varies all the way from 0.05 foot candle in corridors and halls, to 20 foot candles in an ultra-illuminated drafting room. From previous experiences in similar work, it was decided to try an initial illumination of 12 foot candles, making provision that this could easily be increased if it were not perfectly satisfactory.

Of the three systems of lighting, totally direct received no consideration, the choice falling between indirect and semi-indirect lighting. Of course, indirect lighting would give the most perfect diffusion, but such a high intensity coupled with an indirect system would be used only in a drafting room or place where shadows are absolutely impermissible. The assembly of an instrument is carried on best by giving it a slight relief by shadows, as in perfectly diffused light, the perspective is decreased. For this reason, it was decided to use open glass reflectors which by throwing considerable light on the ceiling, would produce a high intensity on the work with a slight relieving shadow and still have a well diffused light for work on flat surfaces.

Color of Walls and Ceilings

In many cases, a pure white wall, while giving the best results, will get dirty so quickly that its efficiency is not only lowered, but it presents an untidy and ugly appearance. In such places, it would be well to paint the walls with a slightly tinted color such as light green or brown. In the present case, however, the room in question was equipped with an air cleaning system of ventilation, resulting in a perfectly dust-proof room, a feature so necessary in the production of a perfect instrument. Therefore, the wall and ceiling were painted with white enamel, giving a maximum of reflection and diffusion,

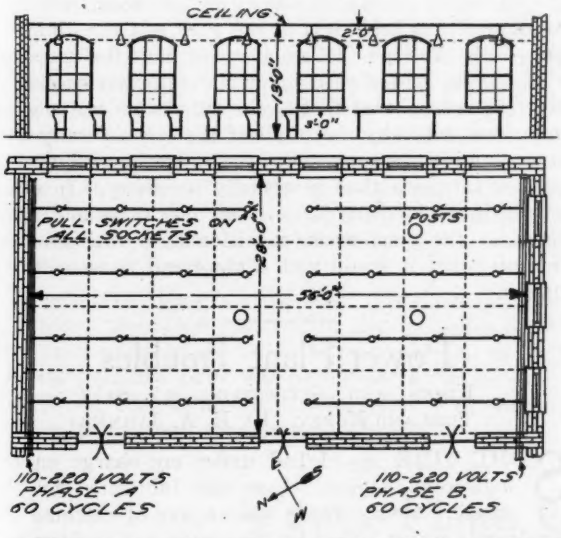


FIG. 13. FLOOR PLAN AND ELEVATION OF ROOM SHOWN IN FIGS. 11 AND 12

with a minimum of absorption of light rays. This enamel, while quite expensive, is easily cleaned, should it become dirty in time, even in spite of such prohibitive precautionary measures as have been employed.

Type of Lamps

In this factory are departments lighted by direct, indirect and semi-indirect lighting, and departments lighted by plain tungsten, daylight tungsten, mercury vapor lamps and arc lamps. From a careful consideration, it was found that the illumination from the daylight tungstens could not be excelled, although the other departments were considered as well illuminated. The decision was therefore made to use daylight tungsten lamps.

In the other departments, different types of reflectors were tried out extensively and the consensus of opinion was that the open glass reflectors made by the Holophane Co. were all that could be desired, in both redirecting the light rays for the direct illumination and the allowing of some ceiling rays for diffusion.

Supply Circuits and Control

The lighting of the whole factory in which this room is located was supplied by a two-phase 60-cycle 110-220-v. three-wire circuit, one phase on one side of the building and one phase on the other. Since this scheme could not be improved, it was adopted for this new department.

TABLE II. ILLUMINATION INTENSITIES COMMONLY EMPLOYED

Class of Work	Illumination Intensity at Work, Foot Candles.
Roadways and Yard Thoroughfares	0.05 - 0.25
Stairways, passageways, aisles, storage spaces,	0.35 - 0.70
Rough manufacturing operations such as foundry work, rough assembling, rough bench work and in fact all work requiring no close discrimination of fine detail.	1.7 - 3.5
Fine manufacturing operations such as fine lathe work, pattern and tool making, light colored textiles, tobacco manufacture, assembling small motors, and any work requiring a moderately close discrimination of fine detail, taking measurements, etc.	3.5 - 6.0
Special cases of fine work, such as watch making, fine instrument assembly, engraving, drafting, dark colored textiles, etc.	8.0 -15.0
Clerical Work, such as is carried on in the average office, accounting, operating typewriters, billing machines, etc.	3.5 - 6.0
Ultra-intense illumination for special cases.	15.0 - 20.0

The subject of control brought up considerable discussion, as other departments reported excellent results with certain group controls. From a consideration of the floor layout, however, it will be seen that the east and south side have natural illumination, so that as the day recedes, the northwest corner must receive artificial illumination first, gradually working toward the east and south. This would result in an odd layout, or if rows running parallel to the east or south side were employed, it would result in much wasted light.

An individual control seemed to be the most satisfactory solution and was accordingly adopted. In this, a long fine cord hangs down from the side of every lamp, and by simply pulling the cord, each workman has the privilege of lighting a lamp in his immediate vicinity as is deemed necessary, finally resulting in general lighting as the day wanes.

The Actual Calculation

After a decision on these main points, the total lumens required was calculated from the formula:

$$\text{Total Lumens} = \frac{\text{Area in sq. ft.} \times \text{Intensity in Ft. Candles}}{\text{Constant}}$$

This formula, together with the constant, was explained in a previous article. For this installation, the constant was taken at 0.65, due to the size of room and perfectly white color of the walls. Substituting in the formula, we get

$$\text{Total lumens} = \frac{28 \times 56 \times 12}{0.65} = 28{,}940$$

For a preliminary trial, divide the room into 18 squares, as this would give 1600 lumens per lamp while a consideration of Table V shows that a 150-w. lamp gives this approximately. For two reasons, this is not satisfactory, however: (1) it results in three parallel rows which must be fed from a three-wire circuit, and with a symmetrical wiring this would produce unbalancing; (2) if it were desired to increase the illumination, it would be necessary to substitute a 200-w. lamp which was considered to be too large.

TABLE V. SHOWING LUMENS GIVEN OFF BY LAMPS OF VARIOUS WATTAGES

Rated and average watts	Mean horizontal c-p.	Total lumens
10	7.7	75
15	13.0	128
20	18.2	178
25	23.8	234
40	38.8	381
60	60.0	588
100	105.0	1032
150	167.0	1635
250	278.0	2725
400	444.0	4524
500	556.0	5655

As a second trial, divide the room into 32 squares as shown in Fig. 13. Dividing 28,940 total lumens by 32 gives 900 lumens per lamp, which is produced approximately by a 100-w. lamp. This results in four parallel rows which will balance the three-wire circuit and allow for a future increase if deemed necessary.

The Actual Installation

In Figs. 11 and 12 are shown untouched photographs of this installation with noontime illumination on a

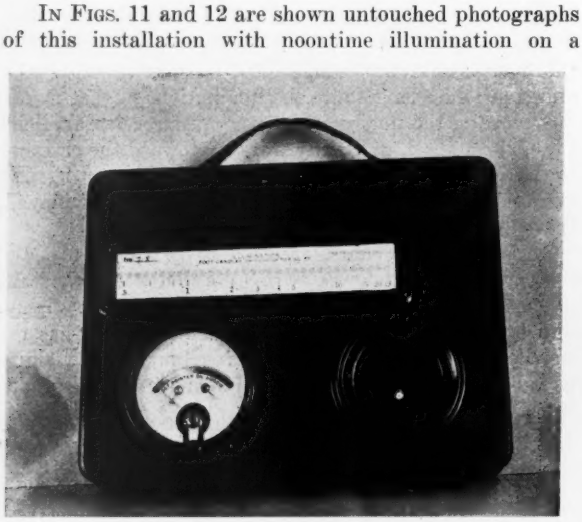


FIG. 14. A TYPICAL FOOT CANDLE METER

bright day and artificial illumination after dark. Figure 12 is not a flashlight, but is produced solely by the illumination described in this article. From the lack of shadows, the perfect definition of every small part and the well-lighted ceiling, it is quite evident that an increase in intensity will not be required.

It is also interesting to note that the illumination as measured by a foot candle meter averages almost exactly 12 foot candles, with, of course, the spaces directly under the lamps and in between the lamps running slightly over and under this value.

The Foot Candle Meter

This very ingenious device is shown in Fig. 14. It contains a small lamp at one end of a long horizontal tube in the side of which are little circles of semi-transparent paper marked with the different values in foot candle intensities. A small battery, an accurate voltmeter and small rheostat insures constant voltage and therefore, constant light from the lamp. This lamp illuminates the under side of the circles, the intensity, of course, falling off as the square of the distance.

To use this instrument, it is merely necessary to place it in the spot where it is desired to know the illumination, adjust the voltage and pick out the circle which appears to be the same color as the surrounding paper. The number by this circle will indicate the intensity. All the other circles will appear lighter or darker than the surrounding paper.

Such an instrument as this is indispensable to the illuminating engineer, as it not only eliminates all guesswork in checking up the final installation, but it enables the desired intensity to be obtained from actual conditions in order that the new system may provide sufficient illumination. For instance, if it is desired to replace an individual drop light system by a general system, say in a machine shop or tool room, the foot candle meter is held right at the work and the illumination read. The new design, however, must be tempered with a great deal of good judgment and experience, as it must be remembered that if the old system has a glare or uneven intensity the pupil of the eye naturally contracts and thus apparently the operation requires a greater intensity than is actually necessary. In other words, if the intensity is uniform, over the whole room, then for the same work, it will not require near the intensity that it would with a glare and uneven illumination.

Power Plant Troubles

Kinks and Suggestions to Save Time and Money. By H. A. Jahnke

SOME TIME ago, I had under my charge an old high-speed engine, which was lubricated by the splash system. There was no way of catching the condensate which leaked by the piston rod packing and this condensate would mix with the oil in the crank case. This mixture of water and oil made poor lubrication for the crank and wristpin bearings and the two main bearings. These conditions were aggravated whenever the piston packing started to leak badly during the day's run. As all parts were enclosed, there was no way to draw up on the gland nuts when the engine was in operation. I tried a long time to find some way of catching this condensate until one day I hit upon the idea of placing a pan under the piston rod next to the packing gland as shown in Fig. 1, at A, then drilling a hole in the engine frame at B through which a ⅜-in. pipe was run from the drip pan to a pail. As condensate was mixed with oil, it was placed in the oil filter. After placing this drip pan, there was very little water in the oil in the crankcase.

Cause of Front Dead Plate Breaking

In a manufacturing plant using sawdust mixed with coal as fuel, much trouble was experienced with the front dead plate in the boiler furnace cracking. This was expensive, as each time this plate was renewed it was necessary to tear out and rebuild the front furnace lining. Nobody seemed to know what caused the trouble, as there was no undue strain on the plate.

When a new engineer took charge of the plant, he saw at once what caused the breaking of the plate so frequently. For feeding water to the boiler, a tilting

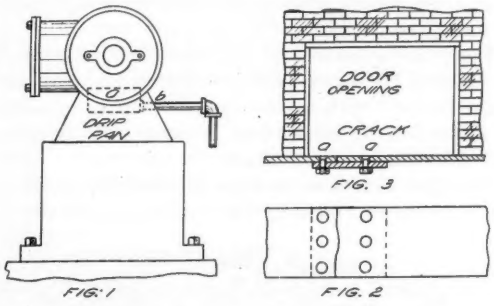


FIG. 1. HOW THE DRIP PAN WAS INSTALLED
FIG. 2. METHOD OF REPAIRING CRACKED DEAD-PLATE
FIG. 3. LOCATION OF CRACK IN DEAD PLATE

trap was used, and the vent or exhaust from this trap was discharged into the ash pit of the boiler furnace close to one of the side walls near the dead plate. Whenever the trap discharged, the exhaust steam and water striking the plate had a chilling effect, at length causing it to crack. The outlet of the exhaust pipe was changed so as to run into the heating system and dry rooms when needed, otherwise outdoors, thereby removing the cause of the trouble.

No new dead plate was installed this time, but the old cracked plate was repaired in the following way. Three holes were drilled in the plate on each side of the crack then an iron plate was placed on the under side as shown in Fig. 2, and bolted together as shown in Fig. 3, with flat-head countersunk bolts.

A Whistle Time Reminder

At one time, I had charge of a plant where it was necessary to blow the whistle at 5 min. to seven and seven o'clock, then again at 5 min. to eight and at eight o'clock. I could not get used to blowing the 5 min. to eight and eight o'clock whistle, as after blowing the seven o'clock whistle, I would get busy at some repair work, etc. and forget all about the eight o'clock whistle until it was too late. Then I hit upon the idea of using an alarm clock to remind me when it was time to blow the eight o'clock whistle. After this, I did not forget the whistle unless I forgot to set the alarm clock. After I got used to blowing the whistle at this certain time, it was not necessary to use the alarm clock.

How to Reduce Fuel Expense

A short time ago, while passing by a manufacturing plant, I noticed a number of steam pipes coming out of the building walls from which steam and water was escaping. In looking into the plant, I saw that this steam and condensate came from the heating system throughout the plant. I was wondering at that time if there are many more plants in existence where the steam and condensate are allowed to go to waste as in this plant.

In the writer's plant, very little condensate goes to waste from the heating system and other steam using apparatus. The condensate runs into a receiver from which it is discharged into the tank of a tilting trap of the lifting type which forces the water into another tilting trap located above, and discharging into the boiler.

The vent or exhaust from these two traps discharges into the heating system along with live steam where the pressure is reduced to about 2 lb. Early this spring, while it still was necessary to turn steam into the heating system for a short time mornings, I decided to try to heat the office and plant sufficiently during very mild weather with the exhaust steam from two traps only. I found that this did the work satisfactorily, thereby saving the live steam for other work more necessary. The condensate from the two traps is also returned to the boilers, and in this way our coal consumption was reduced considerably.

Power Plants Get Rate Increase

California Commission Grants Public Utility Companies Right to Increase Rates 15 Per Cent. By Charles W. Geiger

THE CALIFORNIA Railroad Commission has authorized an increase of 15 per cent on the rates for electric current to be charged by the Pacific Gas & Electric Co. and the Great Western Power Co., the surcharge to continue until April 10, 1921.

This is in accordance with the policy of the commission not at this time to authorize permanent increases in rates charged by public utilities, but to grant aid in the form of surcharges to continue for a limited period "until the clouds roll by."

They are necessary. California needs the development of water for the creation of power, the irrigation of land and for industrial and domestic use. The public needs from the public utilities the best service which can be given and, within reason, the reliability and quality of service is paramount to the question of cost.

These things will not be attained except by the very large and for many years the constant increase of capital investment. It will be difficult to get this investment except by reasonable assurance to capital of reasonable return on that investment or by extorting it from the taxpayers, with the reasonable assurance that there will be no return.

As long as rates for public service are fixed by representatives of customers, the public is certainly in no danger of extortionate rates. Consequently enlightened

public sentiment will favor the granting by rate fixing bodies of whatever rates are necessary to pay for the service demanded.

The Railroad Commission's decision applies to standard rate schedules, which include a basic surcharge permitted in 1918. The increase applies to the Sierra and San Francisco Power Co. operated under lease by the Pacific Gas and Electric, and the Northern California Power Co., recently acquired.

It is an emergency increase to cover increased producing costs and will apply on all bills rendered between July 10, of this year, and April 10, 1921.

According to estimates by the Railroad Commission, the emergency surcharge allowed will produce for the Pacific Gas & Electric Co. an additional revenue of $2,200,000 for the year ending July 1, 1921. Officials of the Great Western Power Co. roughly estimated that $800,000 would be added to the revenues of the Great Western Power.

The production of a large proportion of electric current by steam power, due to the water shortage, increases in wages and the high cost of fuel oil, were among the representations made by the companies in applying for the increase.

Representing the communities about the San Francisco bay at the hearing of the Commission were Assistant City Attorney John J. Dailey of San Francisco, Assistant City Attorney Leon Gray of Oakland and City Attorneys Archibald Yell of Sacramento, W. J. Locke of Alameda and Frank Cornish of Berkeley. The Engels Copper Mining Co. was also represented. At the hearing the Great Western Power Co. submitted exhibits to show that an increase in rates was necessary because of increased operating costs.

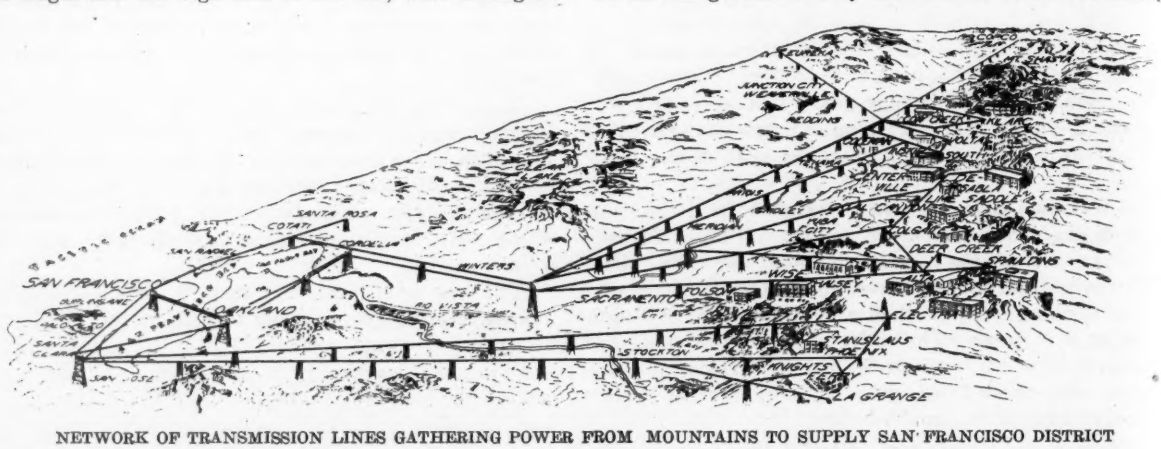
J. D. Black, sales manager of the power company, explained the exhibits as they were offered. He said that the total receipts of the company in 1919 were $5,055,755. He estimated that the receipts for 1920, based on the present rates, would aggregate $5,114,798.91. In 1919, one of the exhibits showed the company's total operating expense and depreciation footed up $2,517,795, giving a net revenue after depreciation of $2,537,960. The same exhibit estimated for 1920 a total operating and depreciation expense of $5,296,928, leaving a net revenue after depreciation, if the present rates were continued, of $1,817,870.91.

It was pointed out that according to the figures submitted by the company production expenses in 1920 would amount to $1,525,268 or $701,950 more than in 1919. The transmission expense in 1920, according to the company's estimate, would run to $151,595, an amount $22,010 in excess of the 1919 expense. Distribution expenses would total in 1920 $58,822 more than in 1919. Taxes would show a decrease of $48,891, the company's estimate for this item totaling $355,000, as against $405,891 actually paid in 1919.

One of the company's exhibits showed an estimate of 112,737,560 kw.-hr. of steam generated electric energy in 1920, as against a steam production of 41,757,450 kw.-hr. in 1919. The same exhibit also showed that the company's hydroelectric production of 375,755,580 kw.-hr. in 1919, would drop to 281,309,580 in 1920, due to low water conditions.

The price schedules of both the Pacific Gas & Electric Co. and the Great Western Power Co. were altered by the decision with a view to removing inconsistencies, the alteration in most cases being merely to simplify the light and power schedules.

The period of nine months allowed for collection of the surcharge was fixed by the Commission on the theory that by April of next year sufficient additional hydroelectric generating plants will have been completed to allow considerable reduction of the more expensive steam power (fuel oil used in steam generating plants is now $1.81 per bbl.).



NETWORK OF TRANSMISSION LINES GATHERING POWER FROM MOUNTAINS TO SUPPLY SAN FRANCISCO DISTRICT

The Great Western Power Co. was ordered by the Commission to bring street lighting rates, power for street railways and other public utilities to the level of other rates, in view of the fact that public utility rates were exempted when the former surcharges were fixed in July, 1918.

The request that the companies be considered separately, which was made by patrons of the original Pacific system, in order that they may be relieved of increase to offset the greater deficit which they contended exists on the Sierra system, was answered by Commissioner Devlin in part as follows:

Analysis has been made of sufficient extent to determine that no injustice is done the consumers of the separate system as a result of the surcharge granted.

No prejudice will be suffered by the consumers of either the former Northern California Power Co.'s system or the former Pacific Gas & Electric system if increases on these systems do not result in an unreasonable return considering the systems separately.

The Commission's decision refers to the high inter-

est rates and the high cost of construction for the power development plans of both the Pacific Gas & Electric Co. and the Great Western Co.

Financing of development work by the latter company, which contended that original cost estimates had fallen short and that construction materials had advanced, was dealt with by Commissioner Devlin in part as follows:

Further financing has been found necessary and the evidence shows conclusively that it is essential that the company be maintained in a strong financial condition in order that the development may be completed and the cheaper power so produced be made available to the public at an early date.

A permanent increase is contingent upon further investigation by the Railroad Commission and cannot be considered in the present hearing, said Commissioner Devlin.

Hearings for the rate increase have been before the Railroad Commission since April 13, when the Pacific Gas & Electric Co. in its application asserted that unless the Commission acted it would meet with serious financial difficulty.

As an emergency measure, pending a complete revision of rates, the Southern California Edison Co. was granted authority by the State Railroad Commission some time ago to increase its charges by an average of 27 per cent, effective April 20, 1920. This will mean an increase in charges of approximately $2,100,000 a year.

Under the new schedule, ordinary consumers will pay an additional 2.16c per kw.-hr., making the total charge 10.16c, compared to the charge of 8c that has been collected since Jan. 1, 1919. Commercial charges will be on a sliding scale.

Among the reasons urged by the company for granting the increase were the necessity of maintaining its financial status; to avert loss to the community it serves; to continue power development to meet with growing demands, which have been threatened by high operating costs resulting from water shortage and the increased price of fuel.

The text of the decision says, in part:

"It is vitally necessary for the continued growth and prosperity of the vast territory in Southern California supplied by the applicant with electric energy that its full program of development go forward without serious interruption. We believe it to be in the interest of the consumers that they pay rates sufficiently reasonable to enable the company to earn a fair and reasonable return upon the actual investment. Unless this is done, it is plain that the utility cannot borrow sufficient funds to carry forward necessary developments. It is of great importance that this program of development go forward; should there be any halt, it is evident that tremendous losses will result to the whole community, if sufficient electric energy is not developed to meet the growing demands. It is becoming increasingly evident that the business life of a community such as Southern California is in a very large measure dependent for its growth and expansion, and in some instances even its continued operation, upon electric energy, and as the cost of steam generation is constantly increasing, the necessity for the cheaper production of electricity by hydroelectric development has become more and more recognized. Of course, it is not to be understood that the Railroad Commission urges the payment of unreasonable rates to stimulate investment in this public utility; but when it is considered that to place this company in a position where it can successfully finance will not result at this time in even an 8 per cent return on investment, it will at once be realized that the burden upon the consumer is not unreasonable. In considering the granting of an increase in rates of the amount herein contemplated, we are especially mindful of the fact that the applicant has been diligently active in the enlarging of its production and transmission facilities since the consolidation of the properties in 1917. It has shown an active determination to carry on development and from the evidence presented, has exerted every reasonable effort to meet the demands of the territory served in the face of difficulties arising from the war period of 1918 and period of readjustment and high cost of money, material and labor which have continued since.

E. H. Rollins & Sons have compiled some interesting data regarding the production of electric power, both in California and in the United States. These data are based upon reports from the Railroad Commission of California and the division of power resources, U. S. Geological Survey.

Figures for California show the following percentages of total power generated which were produced from water power: 1915, 83.5 per cent; 1916, 84.9; 1917, 81.2; 1918, 74.8; and 1919, 69.9 per cent.

These figures clearly indicate the effect of recent "dry" seasons upon the output from hydroelectric plants in California. Whereas California in 1919 produced 69.9 per cent of its total power output from its hydroelectric plants, the United States as a whole during 1919 produced only 37.9 per cent of its electric output by water power. For the first three months of 1920, the percentages of total output which were produced by water power are as follows:

January: United States, 33.1 per cent; California, 59.6 per cent.

February: United States, 33.4 per cent; California, 57.1 per cent.

March: United States, 37.5 per cent; California, 68.8 per cent.

It is evident that generation of electric energy by means of water power is vastly more important to California and its industries than to the United States as a whole. This is becoming increasingly so as California's production of petroleum fails to keep pace with its consumption and especially as California's petroleum resources are becoming depleted at an alarming rate.

This analysis emphasizes the tremendous importance of hydroelectric development in the progress of this state.

"The shortage of electrical power in the country, coupled with the coal shortage in the East and the gasoline shortage all over the country, gives us a man size problem to solve," said William Goodwin of the General Electric Co. recently before the weekly luncheon of the San Francisco Electrical League.

Goodwin gave as his opinion that the only way to solve the power situation is through a campaign of education coupled with co-operative effort on the part of all branches of the electrical industry.

He said: "We must face the fact that some of the largest users of electricity are in extremely bad favor with the people. The street railways are the most conspicuous example of this situation; and until the people as a whole come to realize the vital and necessary relation between their daily convenience and the supply of power, we shall not be able to accomplish much.

"The money for power development in California must come very largely from the East. To get that money, you must convince the Eastern people of the great resources that lie in your Western waterfalls and streams.

"Congress controls the sources of power, and Congress is controlled by the East. We are right now facing the railroad situation. One of the first things that must be done in the interest of conservation is the electrification of the railroads.

"The problem which faces the electrical industry is one which must be solved by the industry itself, very largely.

"That means that the closest kind of co-operation among ourselves is necessary. You have co-operation here in the West, and we are trying to preach the gospel in the East, but it is slow work; but without this co-operation, we cannot secure public confidence and good will, without which we are powerless to help the power shortage that faces us today."

Steam Consumption of Steam Jets

Due to Poor Design or to Lack of Attention, the Cost of Operation May Be Considerable

THE STEAM consumption of steam jet blowers used in producing forced or induced draft is always more or less uncertain. This is in many cases due to the haphazard methods employed in the installation of such equipment, and to neglect afterwards. The actual amount of steam used may run anywhere from 3 to 30 per cent of the total production of the boiler. According to Marks' Handbook, the consumption of a jet in a plant of good design, under ordinary operating conditions is from 4 to 6 per cent of the boiler production.

The object of a steam jet when used in forced draft installations, is primarily to increase the amount of air passing through the fuel bed, by slightly increasing the pressure under the grates. This is done by increasing the velocity of the air passing into the ashpit. When used to create induced draft, the same object is attained by increasing the velocity of the gases passing into the stack, and creating a partial vacuum in the combustion chamber.

Due to the fact that, within certain limits, the greater the steam flow is the greater the air flow will be, it is often possible to increase the steam flow through a poorly designed or incorrectly installed jet, with apparently splendid results, so far as the draft and steam production is concerned. But this also means that considerably more coal must be burned to produce the necessary steam for the jet. The aim should be to produce the draft with the smallest possible amount of steam. Enlargement of the jets, due to the erosion of the steam is a frequent cause of excessive consumption.

In a recent article by D. Brownlie in Engineering (London), it was stated that out of 250 typical British boiler plants 93, or 37 per cent, used steam jets of one type or another as a means of creating a more intense draft. While these figures may not be typical of American practice, in that they were secured mainly from installations of Lancashire boilers, which are uncommon in America, some of the data of tests conducted in 130 typical plants are interesting, showing, as they do, the great variety of results secured in different classes of installations. The average consumption was 6.6 per cent of the steam production, the tests including 19 different types of equipment, 11 hand-fired and 8 stoker-fired. The total number of boilers was 437, and the total coal consumption of 1,000,000 tons per year.

TABLE I. RESULTS OF TESTS ON ONE TYPE OF JET IN HAND-FIRED FURNACES

Boiler Plant.		Actual Net Weight of Steam Evaporated on the Plant Calculated per Boiler per Hour, in Lb.	Actual Steam Pressure on the Jets, Lb. per Sq.In.	Actual Net Weight of Steam Used by the Jets, Calculated per Boiler per Hour, in Lb.	Corresponding Percentage of the Total Steam Production of the plant, Used by the Jets.	Annual Coal Consumption of Plant, Tons.	Annual Coal Consumption of Jets, Tons.
Ref. No.	Type and Number of Boilers on Plant						
1	1 Lancashire	4,869	84	189.0	3.4	2,000	69.0
2	6 Lancashire	5,018	102	137.4	2.6	4,300	109.6
3	6 Lancashire	8,351	134	372.4	3.27	19,000	784.3
4	2 Lancashire	6,272	138	248.0	4.1	4,000	154.5
5	6 Lancashire	7,326	112	307.7	4.2	17,400	730.8
6	3 Lancashire	6,035	151	418.4	5.17	6,250	313.8
7	2 Lancashire	4,500	40	249.3	5.40	3,500	209.8
8	6 Lancashire	6,341	98	264.6	5.75	16,500	697.0
9	6 Lancashire	6,321	96	277.1	6.4	9,500	608.0
10	3 Lancashire	2,754	68	179.0	6.5	3,450	221.0
11	1 Lancashire	4,668	98	316.4	6.9	1,250	86.2
12	9 Lancashire	4,397	70	330.4	7.9	22,000	1,730.0
13	1 Lancashire	3,929	85	369.5	9.4	1,800	113.8
14	4 Lancashire	4,995	108	480.0	9.6	10,000	1,040.0
15	1 Lancashire	4,511	72	436.0	9.9	2,450	244.6
16	1 Lancashire	3,838	84	386.6	10.1	1,480	146.5
17	1 Lancashire	3,472	89	371.5	10.7	1,372	147.1
18	4 Lancashire	3,561	87	470.0	13.2	6,330	836.5

TABLE II. RESULTS OF TESTS ON ONE TYPE OF JET USED IN STOKER-FIRED FURNACES

Boiler Plant.		Actual Net Weight of Steam Evaporated on the Plant Calculated per Boiler per Hour, in Lb.	Actual Steam Pressure on the Jets, Lb. per Sq.In.	Actual Net Weight of Steam Used by the Jets, Calculated per Boiler per Hour, in Lb.	Corresponding Percentage of the Total Steam Production of the Plant, Used by the Jets.	Annual Coal Consumption of Plant, Tons.	Annual Coal Consumption of Jets, Tons.
Ref. No.	Type and Number of Boilers on Plant						
1	2 Lancashire	6,997	144	nil	0.00	4,000	nil
2	1 Lancashire	4,629	107	69.2	1.50	1,760	26.5
3	16 Lancashire	9,528	108	830.6	8.47	79,000	4,321.2
4	6 Lancashire	7,518	108	430.4	5.72	19,000	1,121.2
5	16 Lancashire	4,547	108	284.8	7.47	26,250	1,960.8
6	2 Lancashire	6,421	90	498.7	7.60	7,700	585.2
7	4 Lancashire	2,990	75	233.2	8.00	8,500	680.0
8	6 Lancashire	6,993	106	646.8	9.35	15,250	1,410.6
9	1 Lancashire	2,393	84	217.7	9.60	1,550	148.8
10	3 Lancashire	5,406	84	523.0	9.60	16,500	1,775.0
11	2 Lancashire	5,569	147	565.0	10.40	5,800	573.0
12	2 Lancashire	5,918	160	1,041.0	17.60	5,950	1,223.2
13	6 Lancashire	6,561	81	1,408.2	21.40	17,500	3,745.0

"Although there is naturally some difference in detail between the various types tested, most of them consist essentially of some form of hollow furnace bar through which the steam jets force a current of steam and air, which subsequently passes through the furnace above.

"The method employed for determining the amount of steam used was by condensation of the steam by external cooling, and weighing of the condensed water. A special apparatus was devised for the purpose, consisting of an enclosed horizontal cylinder connected with a long vertical condensing coil. The cylinder is jacketed, and cold water is run through the jacket so as to cool the interior. The vertical coil is also immersed in a large volume of cooling water. In determining the steam used by any particular system of steam jets the apparatus is erected in the fire-hole close up against the boiler. The steam pipe and jet apparatus is then taken out of the boiler furnace and placed bodily inside the

horizontal cylinder and coupled up in exactly the same manner as when in the boiler furnace. The end of the horizontal cylinder is closed, and on opening the steam supply valve the steam-jet apparatus works in the enclosed cylinder for all practical purposes exactly the same as it does in the furnaces.

"Care was taken that the supply valve was open to the same extent as when used under the furnaces, and that the steam pressure on the jets was also as usual. The steam issuing from the jets is condensed in the horizontal cylinder and the condensing coil, and runs out of the end of the coil as cold condensed water, and is weighed direct. There is a very minute pressure in the cylinder caused by the small resistance to the passage of the condensed water through the coil, and this will tend therefore to make the figure for the steam used by the jets very slightly lower than would be the case in the open air in the furnaces, and this slight error, if appreciable, is therefore on the right side. In this way a series of observations were carried out, say, three or four successive determinations of one-half hour each, and if the figures for the several determinations were similar this was sufficient. If there was much difference, a further series of determinations were carried out to get good average figures. A fair amount of judgment is, of course, necessary in these determinations. In the first place, there is the question of the amount of opening of the steam supply valve on the jets. On a ½-in. or ¾-in. pipe, for example, say, three-quarter turn is generally

TABLE III. AVERAGE RESULTS FOR HAND-FIRED INSTALLATIONS

Type of Apparatus.	No. of Plants.	No. of Boilers.	Percentage of Production.	Total Annual Coal Bill, tons.	Total Coal Used by Jets, tons.
Type A	6	17	7.6	20,300	1,538.3
Type B	4	7	4.5	15,400	693.0
Type C	3	6	7.3	9,214	674.0
Type D	18	60	6.3	137,005	8,631.6
Type E	7	22	6.1	55,480	4,491.4
Type F	2	3	3.6	6,650	197.6
Type G	2	4	5.0	6,900	350.0
Type H	3	8	7.7	14,400	1,108.8
Type I	2	6	4.4	8,625	376.1
Type J	1	3	15.25	4,000	610.0
Type K	6	16	5.9	35,346	2,079.5
	54	149	6.6	312,010	20,715.7

the same as full open as regards the amount of steam passed, but in 90 per cent of cases the firemen simply open the valve full open, that is two or three turns, and leave it all day continuously in this position. In such a case, the method of determination is simple, the valve being full open. In some cases, however, the firemen are more careful and work with, say, quarter turn open on an 8-hr. shift for, say, 6 hr., and full open for, say, 2 hr., when cleaning out or when the load is particularly heavy.

"In such a case, the practice of the firemen was carefully observed, and separate determinations were carried out accordingly with the valve quarter turn open and full open. The two results were then averaged up in the proportion of 6 hr. to 2 hr., and in this way a good average determination was secured."

Table I gives the results obtained from tests on hand-fired boilers fitted with jet apparatus consisting essentially of either three or four jets of 3/32 to ⅛-in. holes in ½ or ¾-in. steam pipe, per furnace (six or eight jets on Lancashire boilers) situated under the front of the furnace. The boiler pressure is generally reduced, and the steam supply regulated with a hand valve. The average steam consumption was 6.3 per cent of the total production, but the extremes, 3.4 per cent and 13.2 show the possible variations due to a number of causes.

The steam consumption in stoker-fired plants showed on the whole an average of 0.1 per cent greater consumption than for hand-fired boilers, while the various tests showed figures ranging from 1.5 to 21.4 per cent, as shown in Table II, which covers a typical series of tests. The type of jets used in this series consists essentially of 15 or 16 jets of 3/32-in. holes underneath the furnace at the back, 15 or 16 jets of 3/32-in. holes underneath the furnace at the front, and often one large jet, generally a ½-in. pipe flattened at the end over the top of the furnace (62 to 66 jets on Lancashire boilers). All jets generally on ½-in. steam pipe on full boiler pressure, and with steam supply regulated with a hand valve. The average consumption of this group is about 8 per cent of the total boiler production.

TABLE IV. AVERAGE RESULTS OF STOKER-FIRED INSTALLATIONS

Type of Apparatus.	No. of Plants.	No. of Boilers.	Percentage of Production.	Total Annual Coal Bills, tons.	Total Coal Used by Jets, tons.
Type A. - Sprinkling	25	75	8.00	140,345	7,017.2
Type B. - Sprinkling	16	45	5.35	80,280	4,016.4
Type C. - Sprinkling	7	25	6.00	30,070	1,803.5
Type A. - Coking	4	12	2.50	31,000	654.1
Type B. - Coking	1	3	13.85	5,750	796.5
Type C. - Coking	15	66	8.00	221,960	17,756.0
Type D. - Coking	1	3	7.82	4,900	365.6
Type E. - Coking	9	63	7.50	186,350	13,993.7
	76	288	6.7	704,655	46,017.2

The essential differences between the various types tested were in the number and sizes of holes and the position of the apparatus with regard to the furnace. The average results secured with the various types are given in Tables III and IV for both hand- and stoker-fired boilers.

As will be seen from these two tables the variation between the different types, except in one or two cases, is not as great as might be expected. The results of the individual tests of the various types, however, in most cases show considerable variation as do those in Tables I and II. This would seem to indicate that lack of economy is due to one of two causes, either poorly designed or installed jets or deterioration of jets in use, and that it is reasonable to expect in a well designed installation, a consumption of from 2 to 4 per cent of the total production.

Value of Safety Belt

THE STERLING WORTH of the lineman's safety belt manifested itself recently while Albin Wesley, a lineman employed by the Denver Gas and Electric Co., was working on a pole 50 ft. above a concrete pavement. In some manner, he came in contact with 4000 v. a. c., was rendered unconscious, but prevented from falling, being held suspended by his safety belt. First aid was speedily rendered. Physicians state that he will recover.

Evidently Exhausted Itself

POSSIBLY he was a student in steam engineering. He was a young man with a large book under his arm. Approaching the old watchman, he inquired: "Do they use a steam indicator here?"

"Not now. They did when I first came here, but for some reason they removed the little pipe that stuck up right near the smokestack."

Truck Cost Records

Advantages of Using a Standardized Cost System. Methods and Forms for Truck Costs

IN A BUSINESS employing trucks for hauling material of any kind, it is important to know the cost of operation of each truck. Frequently such costs are kept on a whole fleet of trucks, the cost for the individual trucks being simply pro-rated, according to size, or by some other method. This proceeding should be exactly reversed—the individual costs should come first and the fleet cost should be a total of the figures for the individual trucks.

Individual truck cost records are necessary to be able to pick out those units which do not produce results, due either to mechanical deficiencies or to inefficient drivers or operating schedules. The total cost of operation (including depreciation, repairs, etc.) increases more rapidly as a truck nears the end of its useful life. With individual records, it is a simple matter to determine by comparison when a truck has reached the point where its operation becomes unprofitable by reason of high operating cost.

Whatever form of cost system is used, it should provide for an accurate distribution of cost between various departments, or sections, based, not on a system of arbitrary percentages, but on the time actually employed on each class of work. This requires a daily report card, or slip, with provision for data on time started and stopped on various jobs. Frequently, in a small plant, the engineer is responsible at least for the mechanical condition of the trucks, and he may in some cases be required to keep complete record. Otherwise the record keeping is delegated to a clerk who may know little about cost records. The system employed, therefore, should be simple in operation. The daily report should be such as will require little effort on the part of the truck driver, and should preferably be so arranged as to admit of the data being posted directly out to the daily record sheet from day to day.

NATIONAL STANDARD TRUCK COST SYSTEM, . TRUCK OWNERS CONFERENCE, INC., CHICAGO.

DAILY RECORD, MONTH OF_____; HOURS IN WORKING DAY_____ FROM_____ TO_____ TRUCK NO._____

OPERATING DATA																COST DATA (Posted to Form 3c)															
Date	Weather	Temperature	Number of Trips	Delivery or Pick-up Stops	Total Units (See D) Out	Total Units (See D) In	Miles	Time in Hours and Minutes: Available but not Used Hrs.	Available but not Used Min.	Loading Hrs.	Loading Min.	Running Includ. Stops Hrs.	Running Includ. Stops Min.	Laid up for Repairs Hrs.	Laid up for Repairs Min.	Gasoline or Current Gals. or K. W. H.	Gasoline or Current Cost	Cylinder Oil Pints	Cylinder Oil Cost	Driver Cost	Helper Cost	Cost of Repairs: Ordinary Material Chassis	Ordinary Labor Chassis	Ordinary Labor and Material Body	Accident Body and Chassis	Substitute Vehicle Rental
1																										
2																										
3																										
30																										
31																										
Total																										

FIG. 1. DAILY RECORD SHEET

Standard Cost System

THE METHOD described in the following paragraphs is that advocated by the Truck Owners' Conference, Inc., which has compiled a system known as the National Standard Truck Cost System, forms for which are available, which aims to standardize as far as possible the keeping of truck costs. The greatest advantage of using such a system is that results can be compared with any other costs obtained by the same method. It has the added advantage of being simple to operate.

NATIONAL STANDARD TRUCK COST SYSTEM. TRUCK OWNERS CONFERENCE, INC. CHICAGO.

DAILY SERVICE RECORD (TO BE TURNED IN DAILY) TRUCK NO._____

No. of Trips	Trip Time Leave	Trip Time Return	Delivery or Pickup Stops	Load Units Out	Load Units In	Helper Used	Trailer Used	Month	Day	1919
1.								Accepted for Work at		
2.								Released From Work at		
3.								Mileage Reading Finish		
4.								Mileage Reading Start		
5.								Mileage Today		
6.								Gasoline or K. W. H.		
7.								Cylinder Oil Pints		
8.								Lunch Time Start		
9.								Lunch Time Finish		
10.								Driver		
	DAILY TOTALS							USE REVERSE FOR REMARKS ON DELAYS, WEATHER, ROAD, ACCIDENTS, MISCEL. EXPENSE, ETC.		

FIG. 2. SUGGESTED DRIVER'S DAILY REPORT

NATIONAL STANDARD TRUCK COST SYSTEM. TRUCK OWNERS CONFERENCE, INC., CHICAGO.

MONTHLY ANALYSIS OF OPERATION **FISCAL YEAR_____ TO_____ TRUCK NO._____

	**Insert First Month of Fiscal Year in Season of Fiscal Calendar, etc.												1 Mo. Total or Average	12 Mo. Total or Average
A.	Number of days operated													
B.	Number of round trips													
C.	Delivery or pick-up stops													
D.	Total units_____ out													
E.	Total units_____ in													
F.	Miles traveled													
G.	Gallons of gasoline or K. W. H. current													
H.	Pints of cylinder oil													
I.	Hours available but not used													
J.	Hours loading													
K.	Hours running including stops													
L.	Hours laid up for repairs													
M.	Hours with helper													
N.	Trailer data													
	AVERAGES FROM ABOVE													
B 1	Round trips per day													
C 1	Delivery or pick-up stops per day													
D 1	Total units_____ per day													
E 1	Average units_____ per trip													
E 2	Unit_____ miles per day													
F 1	Miles traveled per day													
F 2	Average round trip distance													
G 1	Miles per gal. of gasoline or per K. W. H.													
H 1	Miles per gallon of cylinder oil													
J 1	Average hours loading per day													
J 2	Average minutes loading per trip													
K 1	Average hours running including stops per day													
K 2	Average hours in service per day													
P	Average speed in miles per hour													
Q.	Estimated running time per mile													
R.	Estimated time per customers stop (in min.)													
S.	Cost per day operated													
T.	Cost per mile													
U.	Cost per unit_____													
V.	Cost per unit mile													

FIG. 3. FORM FOR MONTHLY ANALYSIS OF OPERATION

The first requisite of a useful cost system is a form on which can be entered from day to day all necessary operating data, as well as the daily expense for supplies, fuel, etc. Figure 1 is a good example of such a form. The first part is devoted to operating data, and the second part to cost data. These data are secured mainly from the Driver's Daily Report. The care taken in keeping records on this form determines the accuracy of the costs, which are figured on the forms to be described presently. A suggested form for a driver's report, or Daily Service Record, is given in Fig. 2. Its headings depend on the data required for the Daily Record, Fig. 1. The arrangement shown in Fig. 2 may be changed to suit actual requirements, but the form adopted should contain substantially the data shown.

NATIONAL STANDARD TRUCK COST SYSTEM. TRUCK OWNERS CONFERENCE, INC., CHICAGO.

COST RECORD CAPACITY____ MAKE____ MODEL____ ENGINE NO.____ LICENSE NO.____ TRUCK NO.____

FORM 3A INVESTMENTS		FORM 3B CHARGES BY MONTH OR YEAR	YEAR ESTIMATED	MONTH ESTIMATED	MONTH	MAINTENANCE & REPAIR ACTUAL
		INTEREST* ON @ %				
CHASSIS		TAXES				
STORAGE BATTERY (IF ELECTRIC)		LICENSE				
BODY		ADMINISTRATIVE OVERHEAD				
TOP		GARAGE (RENT, LIGHT, HEAT, POWER)				
PAINTING		INSURANCE				
FREIGHT						
SPECIAL EQUIPMENT						
TOTAL						
SUBTRACT TIRE VALUE						
SUBTRACT STORAGE BATTERY VALUE						
TOTAL (LESS TIRES & BATTERIES) TO BE DEPRECIATED		TOTAL				

**MONTH COLUMN CAN BE FILLED IN ACCORDING TO LIMITS OF FISCAL YEAR USE FIRST SPACE FOR FIRST MONTH ETC.

*AVERAGE YEARLY INTEREST $\frac{A+1}{A} \times \frac{C \times B}{2}$

†IN WHICH (A) EQUALS LENGTH OF SINKING FUND PERIOD IN YEARS (B) EQUALS THE INVESTMENT AND (C) EQUALS THE RATE OF INTEREST

PRESENT BOOK VALUE____

FORM 3C MONTHLY ANALYSIS OF COST

** MONTH	TOTAL FUEL COST	CYLINDER OIL COST	DRIVERS & HELPERS WAGES	REPAIR DUE TO ACCIDENT ACTUAL	SINKING FUND (MILEAGE BASIS)	ESTIMATED OR BUDGET: MAINTENANCE AND REPAIR	ESTIMATED OR BUDGET: BATTERY RENEWALS AND MAINTENANCE	ESTIMATED OR BUDGET: TIRE COST	ESTIMATED OR BUDGET: VARIABLE MONTHLY EXPENSE	ESTIMATED OR BUDGET: FIXED MONTHLY EXPENSE	ESTIMATED OR BUDGET: TOTAL MONTHLY EXPENSE	ACTUAL: MAINTENANCE AND REPAIR	ACTUAL: BATTERY RENEWALS AND MAINTENANCE	ACTUAL: TIRE COST	ACTUAL: VARIABLE MONTHLY EXPENSE	ACTUAL: FIXED MONTHLY EXPENSE	ACTUAL: TOTAL MONTHLY EXPENSE
TOTAL																	
AVERAGE																	

TOTAL COST TO BE DEPRECIATED $____ FOR EST. LIFE OF ____ MILES= ____ PER MILE

TIRE ESTIMATE PER MILE { ACTUAL LIFE BY PAST EXPERIENCE ____ MILES } ____ PER MILE; { GUARANTEED LIFE ____ MILES }

ESTIMATED YEARLY MAINTENANCE & REPAIR $____ FOR ____ MILES= ____ PER MILE BATTERY RENEWAL ESTIMATE PER K.W.H. CONSUMED ____

FIG. 4. FORM FOR MONTHLY ANALYSIS OF COSTS

Monthly Analysis

At the end of each month, the data secured from the daily entries which have been made should be carefully studied in order to learn where, and if, efficiency of the truck operation can be improved. This is most readily done when the proper data are posted to a form such as that shown in Fig. 3. The entries for the lines A to N are taken direct from the Daily Record Sheet. The averages which follow are derived from the data given in items A to N. The last four items can be figured only after the Cost Record has been made out.

As a truck increases in age, although it may seem to be doing as good service as when new, there is a certain amount of depreciation, the rate of which increases, until at the end of a length of time dependent on the usage it receives, the truck becomes economically worthless. It still has a scrap value, however, which is but a small percentage of its original cost. This depreciation is an actual wear, and as such must be charged to operation in order to secure accurate costs. Omission of this figure is frequently the cause of low figures, which do not actually indicate the cost of operation. The justice and expediency of pro-rating the depreciation charges throughout the life of the truck will be seen when it is considered that in a business that has run for, say, 25 yr., requiring trucks to be replaced every 5 yr., there is a periodical expense equal to the first cost of the trucks. These expenditures cannot be called investments, because they are not, in effect, new equipment—they are replacements on account of the old trucks having depreciated to such an extent as to have no economic value.

The amount to be depreciated is properly the first cost of a truck and equipment, less the cost of those parts requiring frequent renewal, such as tires and storage batteries. A certain portion of this amount is set aside in what is termed a sinking fund each month or year until the total equals the investment. There are two methods of determining the monthly charge, to be made to operating costs. One divides the total into equal monthly charges; the other provides for distribution on a basis of miles of life. By the latter method, the total sinking fund is divided by the total estimated life in miles and the resulting figure is multiplied by the number of miles traveled in any month to secure the sinking fund proportion for that month. This is continued until the amount charged equals the original investment.

Another item which is frequently neglected is interest on the investment. This is usually figured on the present book value of the truck at an arbitrary rate of interest, and will therefore decrease in amount from year to year. The simplest method is to figure the total interest during the life of the truck and charge an equal amount into the cost each month.

The Cost Record

A good example of a form for a cost record is given in Fig. 4. Parts 3A and 3B are used to determine the fixed expenses and the depreciation.

The first item on 3B, interest on the total investment, may well be handled in the manner described above; that is, averaging the total amount of interest so as to make uniform annual charge throughout the life of the truck. This figure can be secured by means of the formula given in Fig. 4.

As it is impossible to know just how much will have to be spent on maintenance and repairs, and for tires or batteries, a section is provided in Form 3C, Fig. 4, for an estimate or budget cost, wherein these items may be estimated. Two methods present themselves for obtaining the estimated tire cost; one bases the tire life on past experience, the other considers only the guaranteed life.

Variable monthly expense consists of those items which vary in amount from month to month, and include cost of fuel, cylinder oil, driver's and helper's wages, repairs due to accident, estimated maintenance and repair, estimated battery renewals, and tire cost. The sinking fund is included in the variable expense if handled on a mileage basis. If it is unvarying and charged as a definite fraction of the first cost, it is considered as a fixed expense. The other fixed expenses are given in Form 3B. In the actual variable monthly expense, the actual cost of maintenance and tires is substituted for the estimated. The actual fixed expenses are the same as the estimated figures, unless some item, such as taxes or insurance, has been changed during the year.

In order to know the cost of tires, as well as their performance, it is advisable to keep record, such as that shown in Fig. 5. The whole history of a tire can readily be traced by means of such a record if properly kept.

Probably the most practical method of distributing the costs of truck service to a number of departments is on an hourly basis. The form shown in Fig. 6 is designed for this method of distribution. The total truck hours and the number of hours charged to each department are entered from day to day. At the end of the month, these figures are totaled and multiplied by a suitable rate to be determined from the truck operating cost. The costs can also be distributed over different products, in the same manner as shown for departments.

NATIONAL STANDARD TRUCK COST SYSTEM. TRUCK OWNERS CONFERENCE, INC., CHICAGO.

TIRE RECORD, MAKE OF TRUCK _____ TRUCK No. _____ CAPACITY _____ SIZE OF TIRES FRONT _____ REAR _____

Tire, Wheel or Serial Number	Location	Make	Type	Size	Tire Taken From	Order Number	Initial Tire Value	Tire Mileage When Applied	Date On	Mileage Reading	Date Off	Mileage Reading	Elapsed Mileage	Cost of Repairs	Cost of Replacement	Disposition	Total Cost	Cost Per Mile

FIG. 5. TIRE RECORD FORM

DISTRIBUTION OF CHARGES

Date	Total Truck Hours	Departments						
		Power House	Stores	Foundry				
1								
2								
3								
4								
30								
31								
Total								
Rate per hr.								
Amt'g.								

FIG. 6. SUGGESTIONS FOR A DISTRIBUTION SHEET

To Counteract Shorter Hours

THE INSTALLATION of the most modern machinery, no matter how costly, is a justified and paying investment if it results in increased production with reduced man-power, shorter hours of labor, less efficiency of labor.

In fact, any method of cutting production costs and increasing plant output is receiving serious consideration nowadays by captains of industry—even the little things that they were wont to dismiss with a contemptuous wave of the hand a few years ago.

For instance, factory lighting wasn't considered a matter of much importance less than a decade ago. It wasn't realized and didn't matter much anyhow if operatives did lose some time stopping to rest tired, strained eyes, wearied by poor light on their work. They were mostly low paid people, working long hours, and even under bad lighting conditions production costs were low.

But now there is hardly any such thing as cheap help; hardly anybody works long hours and few exert themselves to produce a full day's output. Every possible idea of science and ingenuity must be taken advantage of to counterbalance the modern attitude of labor.

New factory buildings are mostly windows; old buildings are generally too dark; but it has been found that they can be lighted up a great deal by painting the interior wood, brick, cement or plaster walls with a snow white, washable oil paint having a maximum of light reflecting properties. And it is remarkable the influence a seemingly little thing like this has upon production. Eye strain causes headache. No operative will even try to produce to capacity when not in good physical condition; but his high wages go on just the same. Better lighting removes the cause. Increased output, more accurate work, less breakage and spoiling of materials pay for the painting many times over.

Some Colorado Valuations

According to the Colorado State Tax Commission, the total valuation of the most important light and power companies is as follows:

Arkansas Valley Railway Light and Power Co.	$4,513,490
Colorado Power Co.	6,828,090
Colorado Springs and Interurban Ry. Co.	1,278,370
Colorado Springs Light, Heat and Power Co.	1,990,560
Denver Gas and Electric Co.	11,071,450
Denver Tramway Co.	12,463,200
Trinidad Elec. Transmission Ry. and Gas Co.	1,362,180
Western Colorado Power Co.	2,439,320
Western Light and Power Co.	1,506,060

Safety Engineering

A Brief Outline of the Method of Accident Prevention by Means of Education and Co-operation

CLEANLINESS may be "next to godliness" in many places, but in the industrial or power plant nothing is more important than "safety first." Competent authorities state that ¾ of all accidents are preventable. It will therefore be evident that there is need of a more sincere application of the principles of safety engineering. It is not sufficient merely to install mechanical guards or safety devices of various kinds. The installation of guards must be accompanied by education of those whose work may require them to be in dangerous places, and such education should aim to secure the full co-operation of the employes, without which full success cannot be attained. This means that there must be organization.

A Poor Executive Causes Accidents

A popular fallacy seems to exist regarding the precautions necessary to eliminate or reduce the number of accidents. The idea prevails among some people that all that is necessary is to install mechanical guards, and trust in Providence to keep them in place. Carrying out this idea usually results in such statements as, "Oh, we put guards on the machine time after time, but the men won't use them, so we quit installing them." Infinite harm is thus done to safety activities. Such a statement indicates that those in charge of the safety work are at fault in not having first secured the co-operation of the men who failed to use the guards, and in not having taught them the value of such guards. Authorities are agreed also that an efficient safety organization is frequently equivalent to an efficient department, with the result that production is increased. This article attempts briefly to show how the safety spirit can be engendered in any plant.

Where safety engineering has been successfully applied, results have shown that two-thirds of credit for reduction of accidents must be given to organization and education, against one-third to mechanical guards. The method of application of safety engineering in any plant is largely dependent upon the existing organization and also its size. In the smallest plants, the amount of time required to supervise safety work is not great, and this work can often be handled by one of the executives. If there are several departments, the foreman of each one should make a periodical report to the supervisor, of the status of all work in progress to promote safety, and should include recommendations as to additional guards deemed necessary, and suggestions of how to make unsafe practices safer. The executive should appoint, in each department, a committee of two or three of the workmen, whose duty would be to make periodical inspections, reporting its observations and recommendations to the department foreman.

Larger plants of course require more pretentious organizations, ranging from those employing a safety engineer working in conjunction with the shop committees and foremen, to those in which the safety engineer maintains a complete staff of assistants. The shop committee forms a most important unit in any organization.

The Safety Engineer

To be a successful engineer requires a good knowledge of human engineering. Some types of men have to be pushed, some pulled, some coaxed, some can be handled gently, some must be treated roughly. A safety engineer must be able to judge and handle all these types of men in such a manner as to secure their co-operation. He should have that quality which makes men with whom he talks feel that they are his equals, and which, at the same time, gains for him their respect. These qualities together with good judgment and the ability to put over his ideas, to sell them, both to the boss and to the men, are valuable to the safety engineer. Authority should be vested in the man in charge of safety work to enforce all safety regulations.

The foreman should act mainly in an advisory capacity. He should in the ordinary course of events be the intermediate between the shop committees and the safety engineer. The shop committee should submit all observations and recommendations to the foreman for him to approve and submit to the safety engineer.

The Shop Committee

The method of selecting the shop committee depends upon the size of the plant. In a small plant a single committee can handle all inspections, which should be made once or twice a month or even weekly if conditions require. When there is more than one department each department should have a committee of two or three men. In selecting the first committees, it is well to recognize the old faithful employes by the appointment of at least one on each committee. This has the advantage of adding more weight and importance to safety work in the minds of the men than would a committee composed of younger men. The latter, however, should by no means be neglected, as they are frequently of great value. It is a good plan to change the membership of these committees from time to time. This gives all men, eventually, the excellent training in safety methods incidental to such service. Furthermore, service on a committee gives the men good opportunity for displaying initiative and indicates possibilities in the line of future foremen.

The duties of the shop committee include periodical visits of such frequency as may be necessary to all parts of the plant, to look for unsafe conditions and also see that previous recommendations are being carried out properly.

The Bulletin Board

One of the means of greatest value in creating and maintaining the safety spirit is the bulletin board. In order to be of greatest value, the messages it gives must be presented in an attractive form to catch the eye and must have something of interest to hold attention. Comparatively large type or lettering and few words in a

bulletin are more certain to be read than small type and many words.

In order to get much into few words requires the ability of one with a good knowledge of the psychology of advertising. The work of preparing the bulletins should not, therefore, be delegated to some clerk, but should be done by either the safety engineer himself or someone equally well qualified.

The subject matter of the bulletins should be varied from time to time, always with a view to getting something new or unusual. The history of an accident to one known to many employes will excite considerable curiosity and interest. Photographs of the results of accidents, and others showing unsafe and safe conditions, with short snappy wording, secure more attention than a bulletin board of reading matter, and consequently are of much greater value. Graphic charts showing the progress and result of safety efforts in various departments, create a spirit of competition, which is bound to produce good results. The best method is to present but one idea at a time, play it up big, and change the subject frequently.

Safety Meetings

Safety meetings held at frequent intervals are a means of great value in securing interest. The reason for this is that meetings of this kind come the nearest to personal contact that is possible in most establishments. This is particularly true in smaller plants where it is possible to assemble practically the whole force, once or twice a month. In larger plants where this is not possible, the foremen of the various departments and the shop committees should be brought together, and if their whole-hearted co-operation is secured, a long step has been taken toward securing the co-operation of the whole force. In these meetings an executive should preside as chairman and the safety engineer as secretary.

The safety engineer should be given complete authority over the administration of safety work, giving the results in weekly or monthly reports to the general manager or superintendent. His dealings with any department of the plant should usually be through the foreman, and but rarely directly with the shop committees. Transacting business through the shop foreman gives the latter a sense of being appreciated, which helps to get and keep his interest.

The foregoing remarks are of a general character, which may be applied to any plant, whether a manufactory of machinery or of electricity. Each factory, even of those similar in character, requires individual handling to secure the best results; and the power plant is no exception. One point of great value in the application of these principles in the power plant, is the incentive it offers a committeeman to study. A fireman, for instance, serving on the committee will, on entering the engine or turbine room on his tour of inspection, be impressed by and interested in the machinery there installed, and will conceive a desire to know more about it. Naturally, to be of value to the committee he must know something about the machinery, and if his desire for knowledge is met in the right spirit, he will become a much better fireman.

In the same way, an engineer (especially in the larger plants), who has probably not paid much attention to the boiler room since he quit firing, will again be brought into intimate contact with modern boiler room practice by his periodical inspection trips in the boiler room, with results equally as beneficial as in the case of fireman.

For many of the ideas in this article credit is due to Bulletin No. 47, Industrial Accidents and Their Prevention, by R. A. Ray, issued by the Federal Board for Vocational Education.

Re-using Magnesia Pipe Covering

By A. W. Kramer

A POINT of great importance to be considered in selecting a pipe covering is the question of permanence and the possibility of re-use. Permanence, of course, is always desired, but the possibility of re-using the material is, perhaps, often overlooked. There are upon the market pipe coverings which, when new, exhibit high heat insulating qualities, but after being in use for some time lose their insulating properties, and as a consequence, become worthless both for continued use or for re-use.

Coverings of the molded form possess not only excellent qualities as regards permanence, but are also admirably adapted for re-use. Fibrous coverings, for instance, if once badly damaged, cannot be used again. On the contrary, some of the molded coverings can be pounded up and reapplied as a plastic.

Aboard ship, where one cannot always secure necessary supplies, magnesia covering is often removed from one pipe line to be used on another where its use is more necessary. Length of service apparently makes no difference. The writer has removed magnesia coverings which had been in use aboard ship on high pressure steam lines for 10 yr. and after pounding up and making a plastic, applied it to new pipe lines with excellent success. Of course, where sectional magnesia covering is in good condition, and if it is to be used on another line of the same pipe, the sections need merely be removed from the old line and transferred to the new, without the necessity of pounding. If the lines are of different diameters, however, or if the sections are badly damaged, they are reduced to a powder by pounding or grinding between the fingers. Enough water is then added to the powdered magnesia to make it a plastic mass of proper consistency so that it will adhere to the pipe. In preparing the plastic, care must be taken to mix thoroughly the magnesia with water; no hard lumps must be present.

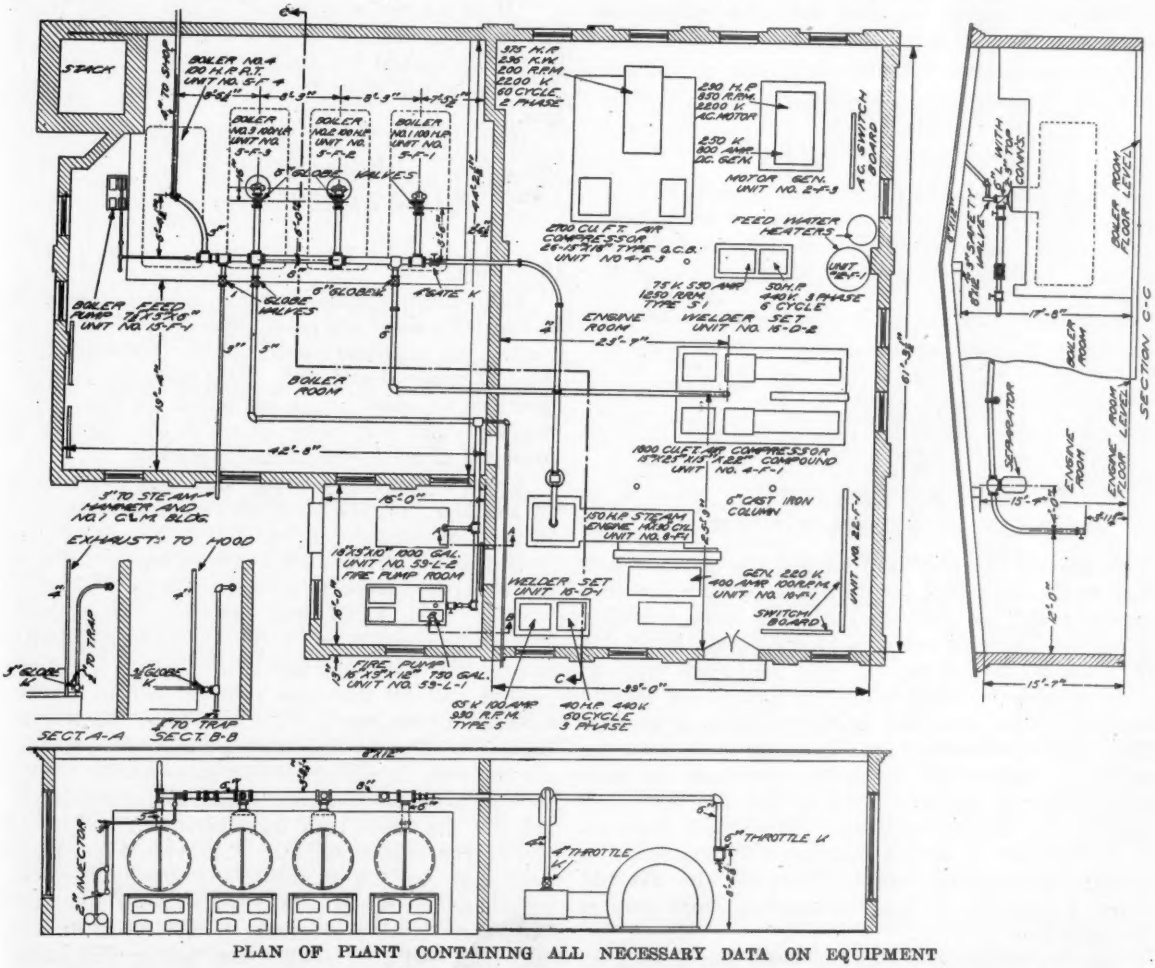
When applying, it is best to have the heat on in the line so that the plastic will dry quickly from the inside. As soon as a small portion of the pipe is covered, it is wrapped with cheesecloth, which serves to keep the covering material firmly in place. This wrapping is generally applied to the magnesia with a paste made of flour and water, and must be applied before the plastic is entirely dry. Care in application is essential. It has been found that a covering carefully applied and the same covering applied in casual manner may show a difference of over one per cent in efficiency.

Defeat is often a spur to victory.—Forbes Magazine.

Power Plant Layout and Data Record

THE ACCOMPANYING illustration shows a power plant layout for a steel works in which I had charge of the engineering end of the game. The plant operates four 50-ton open hearth furnaces and manufactures large steel castings for the Government and private interests. Like many others built years ago, this plant did not have a complete and correct general drawing of the power plant. One would be compelled to look over a dozen or more drawings which were old and worn and then not be sure of getting the correct information.

Plant engineers and others in authority will be well repaid for the labor and time spent making up a correct general drawing of their power plant and it will come in very handy when some of the big boys from the general office happen to blow in and fire away at you (and they do not, as a rule, do it in a fatherly sort of way, either) questions like this: What size and make of fire pump is installed in the power house? Size of engines? etc. Probably a plant engineer who has been employed at a certain plant for a number of years could answer from his experience any question asked him, but it would be a wise thing for a new man in this line to prepare himself for all of the higher-ups. I find that having such information ready where you can put your hand on it at a moment's notice helps convince your superiors that you are on the job. Then, again, do not try to cram a lot of stuff in your head, which will not be of any particular benefit to you when you are compelled to go on another job.



PLAN OF PLANT CONTAINING ALL NECESSARY DATA ON EQUIPMENT

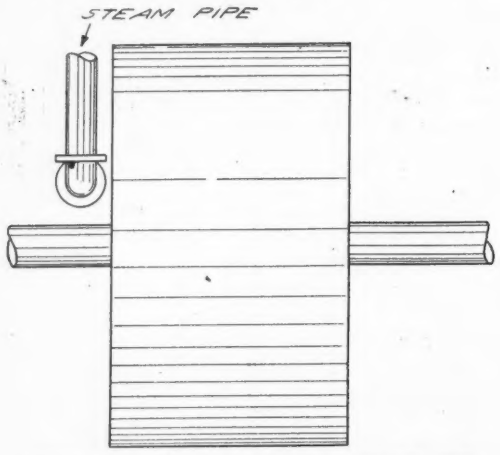
The drawing is not intended to represent a model

power plant, but is intended to show just what equipment is installed with a brief description along with the unit number indicated on each. GEO. W. CHILDS.

Preventing Pulley Slip

WHEN TALKING to the manager of a manufacturing plant, he told me that he had had much trouble with a wood split pulley driving a secondary line shaft from the main line. This pulley would slip much, burning out the bushing, making it necessary to replace it frequently. He had about decided to replace the wood pulley with an iron pulley using a key to hold the pulley securely.

When he showed me the drive, I saw at once where the trouble was. This pulley is located near a steam pipe as shown in the accompanying illustration. This pipe was not covered and it was my idea that the heat from this pipe would dry up the bushing and hub of the pulley so they would shrink to such an extent that the bolts would loosen up, when the pulley would slip, and before the engine was shut down the bushing was burned so badly that it was useless.



THE CAUSE OF ONE CASE OF PULLEY SLIP

To remedy this trouble, I advised the manager first to cover the pipe, then put in a new bushing, drawing up fairly well on the pulley bolts at first, following up on the bolt nuts again in a few days. After this there was no further trouble with the pulley slipping.

In another instance, a wooden split pulley located near one of the line shaft bearings slipped frequently. This trouble was caused by oil getting in between the shaft and bushing and no matter how tight the bolts were drawn up, whenever a heavy load was thrown on the shaft the pulley would slip. The remedy here was to replace the oil soaked bushing with another, first cleaning all oil off the shaft. Then the oiler was told to put a little less oil into the bearings which were of the self-oiling type.

The last section of a long line shaft would slack up frequently for no apparent reason. This section of shaft was connected to the others with a compression coupling on which the bolts were drawn up as tight as possible. The trouble was getting worse, so to locate it, if possible, the coupling was taken apart, when it was found that oil had gotten in between the coupling sleeve and shaft from a nearby bearing. This made the last section of shaft slip whenever a heavy load was thrown on it. The shaft and sleeve were cleaned from the oil and arrangements made so no more oil got between the sleeve and shaft. H. A. JAHNKE.

Qualifications of a Chief Engineer

SOME TIME ago a young man asked me what I considered should be the qualifications of a chief engineer.

I answered somewhat along these lines: "A man to be a real good chief engineer should possess at least three qualities. He, first of all, should be a man, a real man; not necessarily a giant of a man but a true blue reliable man. It is not necessary for him to be able to chew a plug of tobacco a day, or smoke a strong black pipe, or drink a half dozen schooners of ale, but he should have the courage to say, 'yes' or 'no' and also the courage to tell the truth. Second, he must be a good mechanic and know the machinery in his care. And, last of all, he must be able to take part in discussions held in the main office, without signs of stage fright.

"If he is a real man, he will be able to hold his help and fight their battles; if he is a real mechanic he will be able to control his machinery, and if he is a real diplomat he will make the office see things through his eyes."

Well, here's a letter I got a few days ago from this young friend. (By the way, he's not so young now, and I am a few years older too.)

Portland, Me.,
Feb. 1, 1920.

Dear Tom:

You remember some years ago, when you were chief at Buckley's and I was on my first little job at Hovey's, I asked you what you considered the qualifications of a chief engineer should be? You gave me a 15-min. speech on the man part. I was smoking a cigarette, and you said that you never heard of an engineer that amounted to much who smoked cigarettes.

I was going with a young lady (she's looking over my shoulder now, and there are two youngsters playing on the floor) at the time and I told her what you said. She said, "Mr. Thumb is right, Charlie, and I wish you could stop smoking the dirty things."

Well, Tom, I *did* stop. Say, do you know that between you and Mary, I believe I'd have joined the church, if you two had asked me.

I've still got that pipe you sent me for Christmas a couple of years ago, and I often wonder that you never learned to smoke. You know I used to fly off the handle and cuss something terrible and one day when you were in to see me you said, "Charlie, that cussing don't get you any more than the cigarettes did." I asked you if you ever cussed and you said, "Yes, I cuss a good deal, but it's all inside and nobody hears it. I go around sometimes with a smile on my face but my insides are cussing something terrible." Well, I tried that trick and after a while you had nothing on me in that regard.

Then, again one day when I came in to see you, and asked your opinion of a new condenser, you tore my arguments all to pieces and gave me a call-down because I couldn't talk without getting all balled up. Well, I studied and read and after a while I got pretty good on the debate end of the business.

Well, anyway, I got my papers one after another, and my wife says that I never would have gotten them if you hadn't kept after me all the time. And say, Tom, I wondered then if you practiced half of what you preached.

Finally I got the chance to go to Portland at quite a good figure. My Massachusetts license did cut a figure and everything was going along fine, and we were perfectly satisfied, when what do you suppose happened?

Well, an engineer by the name of Howe got through at Bacon & Kent's. He was a mighty good man in the engine room; knew machinery from A to Z, but his help did not seem to get along with him. He had five new firemen in six weeks and he didn't cuss inside. It was all outside! The office called him in one day to tell them the trouble and he flew up and told them it was none of their blankety blank business. One of the clerks told me afterwards. Well, what's the use of prolonging the suspense; Bacon & Kent have given me the position (they came after me) and it means $50 a month more, Tom.

Mr. Bacon said when he hired me, "Mr. Blake, we want you because you don't swear at your help; your engines run smoothly; and your employer, Mr. Smith, says you don't have to take your hat off to any one in his office as a business man. He recommends you because we have a larger plant and can pay more money, and he wants to see you get it. I want you to keep your eye on Mr. Smith's plant until you are sure the new man is O. K."

I'm going to write you a good long letter from the chief's office at Bacon & Kent's some day, when I won't be bothered by the censor. She says not to forget to include her regards in the windup.

CHARLES BLAKE.

Well, you can't blame me for still sticking to my old theories, can you, after reading that letter?

TOM THUMB.

How "Stupid" Became a First-Class Engineer

"STUPID" WAS so called because when he first came into the plant he asked a lot of "fool questions." He asked so many questions, though, that soon the "wise boys" couldn't answer them.

He asked "Skinny," one of the joshers, "What is the matter with the valve on that steam pump?"

Skinny didn't know.

There wasn't an indicator in the plant. Even if there had been Skinny couldn't have used it because he didn't believe in "theoretical stuff."

"Stupid," though, was inquisitive and ambitious. He read a first class power plant publication. He read both the editorial matter and the advertisements. He believed an indicator would do him good, so he invested his savings in one. He learned how to use it. He indicated the pump and rectified the valve setting. Then he went after the steam engines and compressors. He improved them all. And he soon proved to the boss that he was the only man in the plant who knew anything worthwhile.

"Skinny" now takes orders from "Stupid," but he no longer calls him "Stupid." "Skinny" now says, "Yes, Mr. Edmunds." On the other hand, "Mr. Edmunds" still calls the erstwhile josher, "Skinny."

Regardless of what anybody says to the contrary, reading and studying always improve any engineer.

N. G. NEAR.

Eliminating Piston Knock

IN THE ISSUE of Power Plant Engineering of July 1, Tom Thumb suggests putting babbit plugs on the piston to keep it from lifting.

I was asked to give my opinion as to what might be the cause of a heavy knock in the cylinder of a 42 by 48-in. Nordberg Corliss running 92 r.p.m. On taking the piston out of the cylinder, it was found that two of the springs were broken; these were replaced by new springs which eliminated the knock. This engine runs 24 hr. a day and has been running 2 yr. since this repair, and has not given any trouble in the cylinder. As I have never seen a piston with babbit plugs, I do not know what satisfaction they would give; but it seems to me that if the makers of engines had thought them more serviceable, they would use them in place of the springs. I think it is poor policy to try to change the design of machinery after it has been tested and proven that the machine is capable of doing the work under the conditions to which it is subject.

C. J. MILLER.

Flooded Heating System

THE ACCOMPANYING diagram shows an indirect steam-heating system, of which I am in charge. I had been troubled with high water in this system and was puzzled as to the cause of it until I discovered what the trouble was.

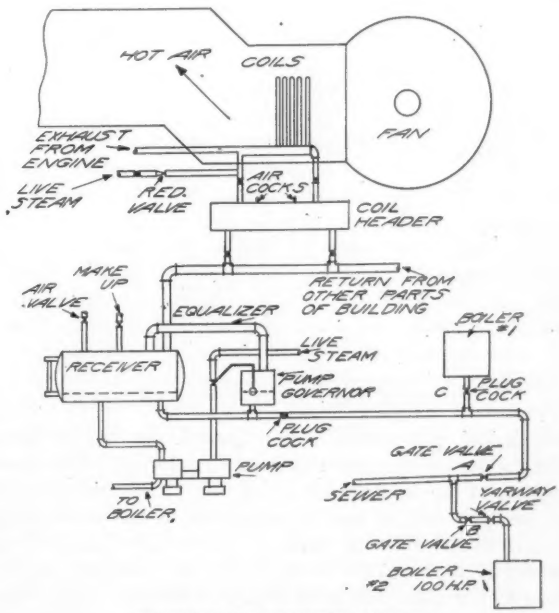


DIAGRAM OF HEATING SYSTEM

The plug cock, shown in the sketch, is 8 in. lower than the bottom of the receiver. The make-up valve, as well as all the live steam valves to the heater are new, so I was certain the flooding was not caused by leaky valves. I did not mind a receiver half full of water, but every morning I would find both the receiver

and heater coils full. If the cocks were opened, a flooded floor was the result.

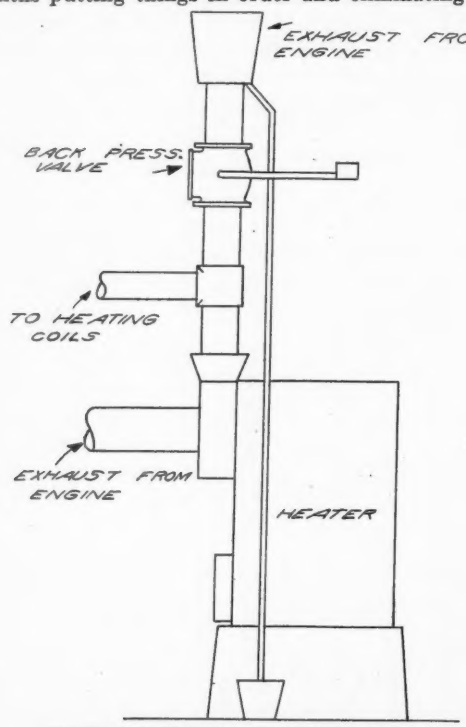
The receiver is 2 ft. below the bottom of the coils. Steam to other parts of the building is shut off every night. In the morning, the system would pump down without difficulty, but I could not understand why it filled up. When the pump was shut off and the plug cock opened, the water would not drain out.

After considerable investigation, however, I finally discovered that valve A was closed. It should have been open, as boiler No. 1 is not in service. When No. 1 boiler is in use, gate valve B is opened, and valve A is closed. Also in blowing down No. 1 boiler, the plug cock at the pump governor should be closed.

R. G. SUMMERS.

Saving Water from Exhaust

THE WRITER sometime ago took charge of a plant of about 750 hp. capacity and was kept busy for some months putting things in order and eliminating wastes,



WASTEFUL METHOD OF PIPING EXHAUST

which had, previously, been tolerated. As one instance, the following will serve as a good example. The steam piping to the feed heater which was of the cut-out separator type was in general as shown in the accompanying illustration, from which it will be noted that all the steam is first passed through the oil extractor on the heater, the clean steam in excess of that needed to heat the water passing up to the heating system supply or out to atmosphere through the relief valve and exhaust head. The writer ran down the drain connection from the exhaust head and found that it was being passed through an old trap, which was out of commission, and discharged to the sewer. This was a needless waste of pure hot water, since all the oil had previously been taken out of the steam. Hence we broke the drain connection and drained it back to the heater where it went to make up the feed supply. Wherever the exhaust is cleaned before it reaches the exhaust head, this drainage should be saved and used as feed supply and not passed to waste.

M. A. SALLER.

A Thankless Job, Sometimes

IN OUR experience around power plants, it is not uncommon to come in contact with firemen and engineers who are not at all progressive. While these men have been in the game for years and perform their work satisfactorily, they do not advance. Many of them have had their fireman's rating for 20 yr. or more, yet they cannot figure the area of a safety valve, and, in my experience, I have met many such men who, in the 20 yr. of their experience in power plants, had not learned how to set a slide valve. These man can start up and operate their chiefs' plants, which are in many instances of thousands of horsepower capacity, with perfect satisfaction, but they do not get ahead. Why don't these men obtain a higher grade license? Lack of opportunity is certainly not the cause of it.

If these men are questioned as to the extent of their reading the current trade journals, it will be found that the majority of them do not read any. A few of them will probably admit that, while they are subscribers to a trade magazine, they have several issues at home which have not been removed from the wrappers in which they were sent.

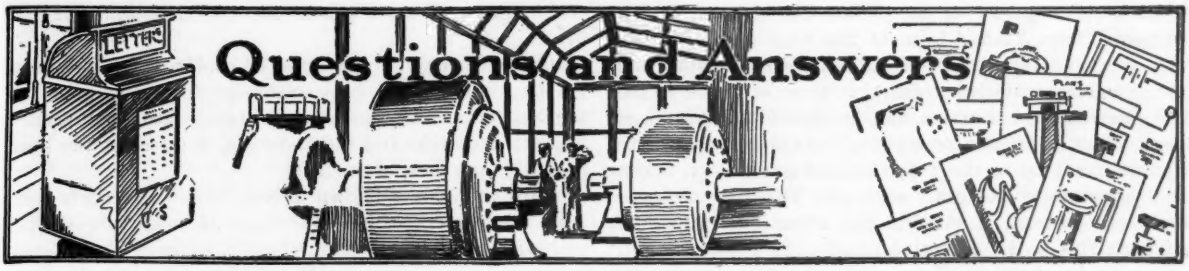
Very often these are the men most lavish in their criticism of everything in general because they have to make three or four attempts in obtaining a license. I have had engine models around the plant, but they have generally grown rusty from want of use, and, in my opinion, such firemen have nobody to blame but themselves.

Reading a trade paper, of course, will not make a man an engineer, but it will give him the benefit of the experiences of others and it will often teach him something in a day which might have taken him years to learn by experience. Many long-service firemen are hostile towards the man who gets ahead by what they term "book learning" and refuse to place any value on it. However, this "book learning," coupled with the practical experience acquired around the power plant in his daily work, has boosted many a man from a fireman's rating to that of first engineer in a few years. And these men, invariably, make good because they combine the theoretical with the practical.

These non-progressive men generally want somebody else to do the studying for them. They maintain that they cannot learn much through reading. This may be true at first, but I tell them to form the habit of reading, little by little, and the knowledge will come gradually. However, my good intentions are generally wasted, and I have offered my services as free instructor upon numerous occasions, only to regret it because of the other fellow's indifference. These men are often working 10 hr. a day or 13 hr. a night and shovel from 5 to 10 tons of coal a day 7 days a week.

My best advice to the young men desiring to get ahead in this business is to read as much of the literature on the subject as possible.

S. B.



Chain Grate Air Supply

I NOTE in your July 1 issue a question which involves a principle so fundamental in stoker design that I would like to reply to it.

There is no question as to the varying resistance of the fuel bed on a chain grate. If it were not so, it would presuppose an invariable condition of the fuel bed which, of course, is inconsistent with the idea of progressive combustion. As a matter of fact, the resistance to the passage of air varies with every foot of travel, and also the amount of combustible matter requiring air contact. It is this basic characteristic of a chain grate fuel bed that is back of the criticism that the chain grate admits too much air at the rear or thin portion of the fire.

Under natural draft conditions, a relatively small hole in the fuel bed or a fire a few inches too short will affect the flow-meter adversely. Anyone who has conducted careful tests for efficiency with this type of stoker will fully appreciate this.

When the chain grate is provided with some means of interposing artificial resistance at the rear to make up for the decreased resistance of the fuel bed, a superior result is obtained. It is, of course, difficult in practice to place artificial resistance of variable type to suit the varying fuels and fuel bed resistances. It is really only when the entire air flow is artificially controlled that we approach ideal conditions. If left undisturbed, the natural law will apply that the air will follow the path of least resistance.

JOSEPH HARRINGTON.

Eliminating the Smoke Nuisance

IN THE June 15 issue, A. R. K. requests information in regard to preventing smoke. This question is important to a large number of people in different ways. Starting with the coal miner who is belated in production, then comes the consumer with a loss which ranges from 5 to 30 per cent by inefficient combustion. After that, the losses to department stores, merchants, residences and laundry women.

Today there are on the market many types of smoke consuming apparatus which carry numerous kinds of guarantees with varying results. Yet a strictly smokeless stack is not always a sure sign of economical combustion. In order to secure these ideal results it is quite necessary to have some tools to work with, an Orsat, draft gage and some candles. Stepping into A. R. K.'s plant, we will proceed to examine the brick work with the candle flame. After finding the setting to be in good order, we can proceed to get analysis of the flue gas. In order to do this, we will insert a length of ⅛ or ¼ in. gas pipe through the rear door which is used for the soot blower. This pipe should be long enough to reach the most active currents of gas as it leaves the boiler. After connecting up the Orsat, we make five or six preliminary analyses in the shortest time possible. Moving the pipe to a new position with each sample, the position giving the best CO_2 reading is the proper place to maintain the sample pipe. Now we can attach our draft gage and note the conditions in the furnace, such as the depth of fire, color and evenness.

Waiting till the blower speeds up and a fresh fire thrown in, we read the draft and analyze as rapidly as possible, reading the draft gage with each sample. This should be continued till the blower has slowed down. The probable readings will be 5, 6, 7, 9 and 11 per cent CO_2, then gradually declining to a low figure. By repeating this test several times, and noting the fire and draft at each high reading, we will find that about the time the smoke disappears the fire has the appearance of a snow bank on a bright winter day. With this condition, the CO_2 reading should be 12 per cent or better. These conditions should be maintained and will require the concentrated efforts of the fireman in regulating the blower and firing intervals.

With a fairly uniform demand for steam, it will be advisable to regulate the damper and blower by hand. This seems like an antique method to pursue, yet we have a condition requiring nearly a constant amount of coal, which requires a certain draft and air supply. This supply has been determined by the preliminary analysis. So far we have established a certain depth of fire, with the correct amount of draft and air supply. This should put the furnace in a position to produce fairly good results. Although these methods will not entirely eliminate the smoke nuisance, I think it will be reduced to a stage where complaints will cease to mature and there is a possibility of putting the load all on one boiler.

In one instance where CO_2 analyses were conducted, it was necessary to put the load from three boilers onto one boiler in order to get satisfactory readings.

There are many kinds of furnaces designed to abate the smoke nuisance and some are very successful if they have the proper attention. No furnace performs its functions without attention and some require more than others. I would not advise any changes in the furnace other than making it air-tight unless it is impossible to get results.

GROVER C. WETHERBEE.

High Furnace Temperature Problem Solved

IN VIEW of the discussion which was aroused by my inquiry, what we did to overcome our trouble of grates burning and arch spawling under Heine boiler will probably be of interest to many.

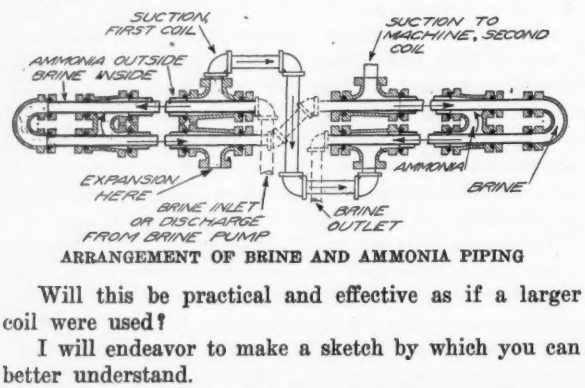
In the first place, we installed a flat tile arch which we raised from 22 to 34 in. at the back end; this has prevented the furnace tile from cracking and spawling off. Then we installed a different type of grate, called self cleaning, which makes and breaks at both rear and front. This has shown no signs of burning except where a point sticks up in the fire; this new grate is on about three-quarters of the grate surface. The other quarter is the old pattern, and I find that these burn some. I attribute this to the collection of ash which does not fall out—thereby shutting off the air.

I also put a grating platform in place of the solid board one that was over the ash pit in front of the furnace, so a greater volume of air can pass. I found the air currents were very sluggish in front of furnace and helped this condition by removing about 2 ft. of planking from bottom of coal bins which had been built up 8 ft. high and about 8 ft. back, also opened all windows possible over coal bins to allow fresh air to find its way under the grates. This all has helped some, but, I think the real reason for some of our trouble is we have not enough stack draft—only about 0.5 in. at breeching; we could not baffle the boiler on second row, tubes were too close, so we put on bottom 3 rows—C tile over fire, and from there back to rear opening put on T tile. This seems to work out all right. I am having no trouble with smoke at present. Furnace looks good, tubes look good; we are saving coal and increasing our capacity.

RICHARD A. CARL.

Increasing Capacity of a Refrigerating Plant

OUR DOUBLE-PIPE brine cooler has become too small for future use. What we want to do is to put another brine cooler in the same room at the same elevation as the one there now, and use but one expansion valve and one suction valve, as though one coil, and passing the brine from the first into the second set of coils as to one coil.



ARRANGEMENT OF BRINE AND AMMONIA PIPING

Will this be practical and effective as if a larger coil were used?

I will endeavor to make a sketch by which you can better understand.

According to this, the brine is inside and the ammonia outside the pipes, and the brine and ammonia circulate in opposite directions. Would this be good practice and should the brine be passed through the first coil or the second coil first?

If pipes of different coils were of different sizes, which one should receive the expansion line? Also the brine line? J. D. B.

A. It is not advisable to connect two double-pipe brine coolers in series. One objection is the added friction in the brine pipes. This friction will mean the consumption of more power for the circulation of the brine.

The efficiency of this type of cooler is great, owing to the high rate of heat exchange from the brine to the ammonia. The greater the temperature difference between the brine and the ammonia, the greater the heat exchange per foot of surface.

Now that this is known to be a fact, it is readily seen that the circulation of the brine through the second coil will result in but a small per cent gain in refrigerating capacity. This is due to the small temperature difference that will exist in the second coil.

If floor space demands that the two coolers be placed in line with each other, instead of side by side, it is not a difficult job to pipe them up so that either one of the two can be operated by itself at such times when the load is not great enough for both.

Extend the present ammonia liquid and suction lines and connect into the two coils, using two expansion and two suction valves. Connect the brine in the same manner.

Two units connected up in this way will be found to give better service than one larger cooler. There are times of the year when one will take care of the load; and there is always a chance of a cooler of this type freezing up and so causing leakage of an inner pipe. With two coolers, an accident of this kind will not tie up the whole system.

A very effective way of increasing the capacity of the plant would be to install evaporating coils in the brine receiving tank. Use 1¼-in. pipe and return bends that will allow a space of about 1 in. between the pipes of the coil. Connect the coils to a top and bottom header, feed the ammonia in at the bottom and take the suction to the compressor from the top.

Pump the brine from this tank and through the coils in the storage rooms, and return the brine to the tank through the double-pipe cooler.

If two coils, made up of different size pipe, are to be fed by one expansion valve, it is best to connect the expansion valve to the smaller pipe first. This will allow for better withdrawal of the evaporated ammonia, as the velocity of the gas will not be retarded. As ammonia is evaporated by the heat, its volume increases.

For brine coils, it will make no difference whether the brine enters the larger or smaller coil first.

If the two double-pipe coolers are connected in series, be sure that the warm brine enters the coil where the ammonia leaves, and leaves the coil at the end where the expansion valve is located. The sketch has the brine arrangement wrong, if it is desired to gain full benefit of the counter current effect.

A. G. SOLOMON.

Filter Problem

REFERRING to J. T.'s inquiry, "Is the filter big enough?" let me say that without knowing all of the controlling factors, no rational answer can be given.

The degree of turbidity, color, suspended matters; the presence or absence of iron in the dissolved or insoluble state; the alkalinity; are properties of the raw water which must be known.

Has the water received preliminary treatment by pre-

filtering, settling, screening, or by the addition of alum, Boothal, or chlorine?

Proper preliminary treatment will often greatly decrease the filter area required.

How frequently is it intended, or is it possible to clean the filter? A clean filter will naturally pass the water quicker than a dirty one.

Are provisions necessary for filtration, while the filter is being cleaned, or are the shut-down periods of the mill sufficiently long and frequent to permit of a shut-down of the filter?

It is, of course, essential that the filtered water should be as free from color and turbidity as it is possible to make it with reasonable expenditure, if it is to be used in paper making. In addition thereto, is the water to be used for drinking purposes and for boiler feed water? If so, it may have to be treated differently from what it would otherwise.

The rate of filtration proposed, namely about 19,500,000 gal. per acre per day, is a very high rate, and I doubt seriously that even under the most favorable conditions the filter would pass the water at this rate under a maximum head of 2 ft. on the sand surface.

If my understanding of the sketch is correct, the pump suction is not directly connected to the underdrains, but merely enters the suction chamber. Under this condition, there will be no suction or negative head on the filter underdrains.

J. T. should consider also that the rate of filtration will be materially reduced when the filtered water begins to accumulate in the filtered water chamber, and that he should provide some means for controlling the rate of filtration and for adjusting the head of the filter.

A. E. HANSEN.

Charging Battery Direct from Generator

I HAVE a 32-v. 80-amp.-hr. battery and want to ask you how I can charge this direct from a 220-v compound wound generator. W. F.

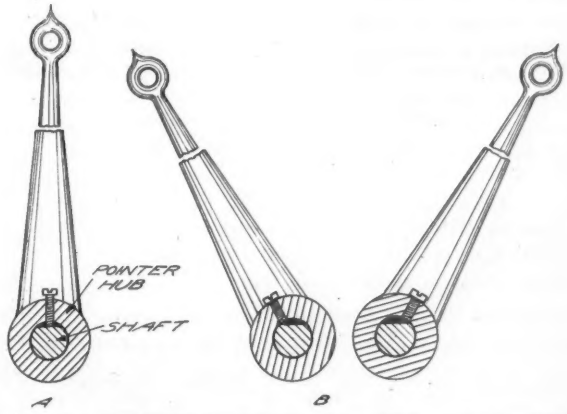
A. A most economical way to do so would be by reducing the voltage of this machine either by means of your field rheostat or the speed of your driving unit to such a point as to cause the generator to produce a voltage of 32 or perhaps slightly more. Of course, it is possible to insert a resistance in series with your battery; but the drop in voltage through this resistance and considering the current flow, would be such as to result in the waste of an enormous amount of energy, and would require a most bulky and unwieldy piece of apparatus.

Probable Cause of Synchronizing Trouble

READING of the troubles of J. M. E. about synchronizing difficulties caused by instrument errors, in the July 1 issue, brings to mind a similar case where the writer was called in to investigate similar trouble with paralleling machines. The synchronoscope (previously called "synchroscope") appeared to rotate correctly and it was noticed that when the incoming machine was running slightly fast and was thrown in at synchronism, there was not a bit of trouble, but when the incoming machine was running slow and was thrown in at synchronism, there was a decided disturbance and "grunting."

Connecting a portable synchronoscope in parallel with the station synchronoscope revealed the fact that the station synchronoscope was over ¼ in. off when running from the slow direction, but was correct when rotating in the fast direction. Removing and dismantling the instrument quickly revealed the cause. The pointer was supposed to be fastened onto the moving element shaft by a small setscrew and there was a flat on the shaft to receive the setscrew; but the screw was too short to reach the flat and allowed the pointer to turn about ¼ in. before striking the sides as shown in the accompanying illustrations. A longer setscrew entirely eliminated the troubles encountered.

It must be remembered in synchronizing with the incoming machine running slightly fast or slow (say about one revolution of synchronoscope pointer in 5 to 6 sec.) that the switches must be closed slightly in advance of synchronism if automatic switches are used. In other words, the closing of control switches must be so timed that the actual closing of the generator circuit is made at synchronism. This little point has been responsible for much trouble by operators who closed control switches exactly at synchronism instead of slightly in advance. V. H. TODD.



(A) WITH SUFFICIENT SETSCREW LENGTH THE POINTER HUB IS HELD SECURELY IN PLACE

(B) IF, HOWEVER, THE SETSCREW IS TOO SHORT CONDITIONS WILL BE AS HERE SHOWN

Gage Cock Location

WILL YOU please answer the two following questions?

1. Where is the water gage and gage cock put on a vertical fire-tube boiler having flush tubes?

2. Is there any difference between vertical stationary boilers and vertical portable boilers such as are used on locomotive cranes? G. L. M.

ANSWERS

THE WATER GAGE of a vertical fire tube boiler is so placed that when the water level is at the proper height it is about halfway in the gage glass. The water height is usually about ¾ to ⅞ of the distance between the fire box and the top of the boiler.

2. There is no substantial difference between a vertical stationary boiler and boilers that are used on locomotive cranes.

POWER PLANT ENGINEERING

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Research in the Power Plant

It is extremely rare that a power plant, no matter how small, does not have a number of problems which must be worked out on the job. Scientific investigation has not as yet reached the point where the solution to all problems is known once the conditions are stated, because these conditions are forever changing.

It behooves the engineer, therefore, to make of his power plant a laboratory for investigating the solutions of his problems which will result in more reliable and efficient service, better and safer working conditions for the employes.

No matter in what manner the solution of any problem is worked out, that solution will cost money and time, so the quickest and least expensive method to arrive at the correct solution is the most desirable. It is for this reason that scientific research, wherein conditions which influence results are studied one by one, the effects of variations noted, and progress made from the known to the unknown, has been adopted in the most economical power plants. In one plant where a regular laboratory staff is maintained, a study is being made of boiler efficiency and life; condenser and lubrication problems; furnace design and heat loss. In another important power plant of the central station class, investigations are being made on insulation deterioration, potential rises due to switching operations, heat dissipation, electric furnaces and storage batteries.

These plants are cited merely to show that even in the largest plants investigation does not stop when the common problems have been satisfactorily solved.

But in the plant where it is impracticable to maintain a corps of research engineers, scientific methods are still available and, being less expensive than the haphazard method of cutting and trying, they should be adopted. The ground work for such investigation is an adequate system of records extending over a period of time sufficient to give average results for the prevailing conditions. With these general records available, any specific problem may be studied with intelligence; without them the engineer's investigations are sure to be unnecessarily expensive.

With fuel as uncertain as it is today; nearly all classes of labor in a state of turmoil, a large percentage of the power plant equipment of the country overloaded and worn by hard usage during the war, and deliveries six months to a year off, there was never a time when research would pay better returns than today if it is conducted along the proper lines.

Off Duty

In these days of 60,000 kw. generating units and 7000 hp. boilers, we engineers are apt to be filled with no small measure of self-importance. And rightly so—why shouldn't we? Such enormous machines are truly monuments to engineering progress and their achievement is something for every engineer to be proud of.

Don't, however, let our accomplishments become so big in our own eyes, that we cannot see over them and thus fail to give credit to those in other fields of endeavor whose work may not be so impressive but in every way as wonderful. We are, each, experts in our own line only. If a man cannot build and operate a turbine, he

can probably do something else of equal importance. Said the squirrel, when he and the mountain had a quarrel, "If I cannot carry a forest on my back, neither can you crack a nut." And, to use a slang expression, that squirrel "said a mouthful" when he uttered those wise words. There are other fields which deserve credit as well as our own.

For instance, at the University of Chicago, there is a machine which rules lines on small polished metal plates—a ruling machine, so to speak.

Now, of course, we are all familiar with the lines (divisions) on our foot rule or steel scale. They generally run 8 or 16 to the inch on our rule, while on the steel scale as many as 64 or even 100 are crowded together in an inch. The latter we all admit are a bit close and none of us would fancy the job of ruling an additional line between each of the hundred divisions.

"There wouldn't be any space left between the lines after we got through," would be our argument.

And, perhaps, there wouldn't—not with our clumsy methods.

Were the ruling engine of which we spoke endowed with a conscience, however, it would not in the least object to such a task and would accomplish it without the slightest difficulty.

"A remarkable machine," we say. "It must be very accurate."

And so it is—a very remarkable machine.

Indeed, this machine is capable of drawing 300 lines between each of the 100 divisions! Three hundred, think of it! Thirty thousand lines to the inch!

"Impossible," we exclaim, nevertheless it is an absolute fact, and what is more, in ruling these lines, the amount of error would at no point exceed one hundred thousandth of an inch.

This machine is used for making diffraction gratings for use in astronomical observatories in analyzing light. A beam of white light directed against such a grating is resolved into its component colors, just as a beam of sunlight passing through a glass prism, is resolved into the "colors of the rainbow."

By means of these gratings, the light from a distant star, billions upon billions of miles away, is made to tell the story of its composition—what it is made of. And it does this with unfailing accuracy. It was by this means that the strange element, now known as Helium, was first discovered in the sun. And once, this gas had been discovered in the sun, the scientists began to search for it, here on earth—and lo, and behold! they found it. Now we are preparing to fill our dirigibles with it, for it is non-explosive and therefore far more safe than the hydrogen gas usually used for filling balloons. So without question, these diffraction gratings are valuable.

These plates, some of which are 6 in. square, are made of a special alloy called speculum metal, the polished surface of which is ruled with lines—from 15,000 to 30,000 per inch. The ruling is done with a diamond point.

When in the process of making, say a 6 in. plate, the room in which the machine operates is sealed and the temperature is kept constant to within 0.01 deg. C. by electrically operated thermostats. During the four days or a week which is consumed in the ruling of a plate, no person enters the room, since the heat of a human's body would instantly throw the delicate mechanism out of adjustment, and ruin the plate. It must further be free from all vibration and external shocks.

Power Plant Slogans

Store Coal in Summer.
Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

In making gratings, the periodic error must be very perfectly eliminated, since the recurring displacement of the lines of only one millionth of an inch from their mean position will produce "ghosts" in the spectrum. As a further complication, some of the gratings are concave, and produce direct images by reflection without the aid of other optical apparatus.

There are various copying processes by which it is possible to reproduce an original ruling in more or less perfection. At the present time excellent reproductions of speculum metal gratings are on the market, prepared after a suggestion by Sir David Brewster, by coating the original with a varnish of celluloid. When dry, this film of celluloid is stripped and mounted on glass. Much skill is required to be sure that the film when stripped shall remain undeformed.

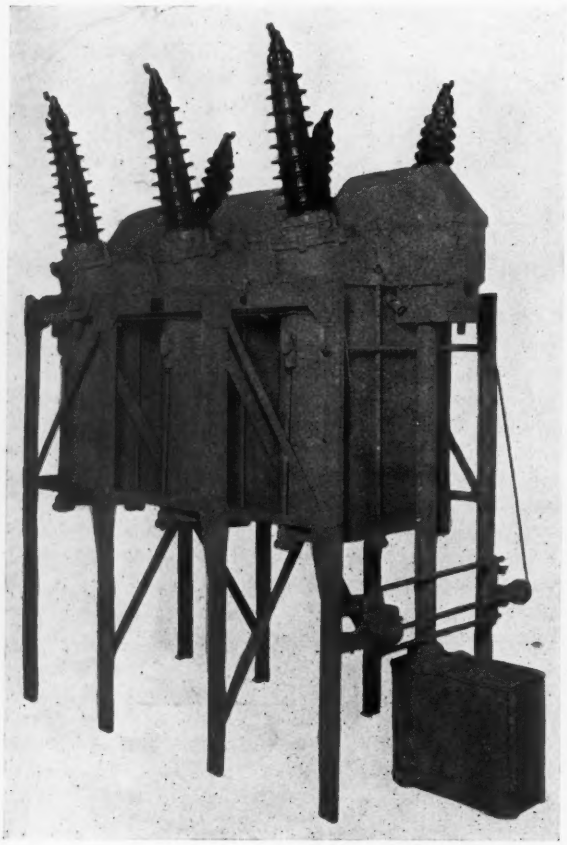
As can be imagined, the screw for this ruling engine must be as nearly perfect as human endeavor is possible to make it. Weeks and months are spent in grinding it and examining it under the microscope for imperfections. It is generally turned from a bar of soft Bessemer steel, which has not the hard spots usually found in case steel. This bar which is almost 30 in. long is placed between lathe centers and turned down to 1 in. diameter everywhere except for about 12 in. at the center where it is left a little over 1⅛ in. The screw is then cut with a triangular thread a little sharper than 60 deg. The grinding unit, which is 11 in. long and made of brass or Bessemer steel is next placed upon the screw and the whole placed in a lathe. To insure accuracy in grinding, the screw and nut is surrounded by water, the temperature of which can be kept constant to 1 deg. C. and in order that the weight of the unit may not make the ends too small, it must either be counterbalanced by weights hung from a rope, or the screw must be vertical during the whole process. Emery and oil are best for grinding although a softer silica powder might be used toward the end of the operation which consists in turning the nut end for end, every 10 min. without interruption for about three weeks. The screw is then ready for examination under the microscope, where any defects that may be found are corrected by hand.

So here at least, we have one product outside of our own field well worthy of our attention and admiration. And there are countless others, many of which we hope to be able to discuss in our future Off Duty talks.

Recently Developed High Voltage Oil Circuit Breakers

A NEW LINE of high-voltage oil circuit breakers, with voltage ratings from 15,000 to 155,000 has been developed. There are two types of these breakers, one for indoor and the other for outdoor use, both being the same except for the enclosure of the solenoid, and the use of low temperature oil in the outdoor type where the temperature is below 0 deg.

The bushings of these breakers are interchangeable with oil circuit breakers, lightning arresters and power transformers, and above 73,000 v. for instrument transformers of the same voltage rating manufactured by the same company.



HIGH-VOLTAGE OIL CIRCUIT BREAKER OF THE TRIPLE POLE SINGLE-THROW TYPE

For voltages above 73,000, bushings adapted to all altitudes of installation can be supplied and mounted on breakers, without other structural change in the breakers, thereby making it possible to keep the same voltage rating of a breaker at various altitudes.

The breakers are built in three interrupting capacity sizes for each voltage above 15,000 v., and for 15,000 v. in the medium and the large sizes, the principle of operation being the same in all cases, but with a variation in some of the constructional details. The contacts on the smallest size are of the finger and wedge type, while the others are provided with plunger contacts and also equipped with explosion chambers. While the contacts are the same on the two larger sizes, the interrupting capacity has been increased, on the largest size by immersing the contacts more deeply in the oil, at the same time increasing the size of other structural features.

The breakers are all triple pole, being made up of three single-pole standard unit elements, each element consisting of the mechanism, covers, bushings, and oil tank. The mechanism of all breakers can be removed without disturbing the rest of the breaker. The tripping mechanism and springs are all easily adjustable, all that is necessary being to remove sections of the covers, so as to make the parts accessible.

These features, combined with the interchangeability of the parts and the simplicity of construction, make these types of oil circuit breakers highly adaptable for any class or condition of service which may arise, regardless of climate or altitude.

Production of Bituminous Coal

ALTHOUGH unable to maintain as good a car supply over a six-day week as during the five-day week preceding, the railroads provided transportation sufficient to produce 10,969,000 tons of soft coal during the week ended July 17. This was the largest output in any week since March 27, before the switchmen's strike began, and except for that week, the largest since the middle of January. In comparison with the latest full-time week (June 20-26), the output showed an increase of 413,000 tons, or 4 per cent.

On the five working days of Fourth of July week, an average rate of production of 1,923,000 tons had been reached, and the line of 1920 production has crossed the 1917 line. The lead thus established was maintained during the week of July 17. The present rate is still far short, however, of that of the summer of 1918.

Production during the first 169 working days of the last 4 yr. has been as follows (in net tons):

1917, 299,772,000; 1918, 313,867,000; 1919, 238,213,000; 1920, 282,945,000.

The year 1920 is thus nearly seventeen million tons behind 1917, and nearly thirty-one million tons behind 1918, but is forty-four and three-quarters million tons ahead of 1919.

Scattering strikes were reported from several localities, but reached significant proportions in only Alabama, Kansas, and Arkansas. In the Kenova-Thacker field, the labor loss was 75.2 per cent of full time.

No slackening was observed in the intense demand which has characterized the market in recent weeks. Not a mine east of the Mississippi and but few west of that river reported losses due to lack of orders.

The presence of the holiday makes the returns of losses on account of transportation disability difficult to interpret. It is clear that a part at least of the very general reduction in the percentage of transportation loss was due to an absolute improvement in car supply, as well as to the decreased demand for cars caused by the holiday.

Movement to the Lakes during the week ended July 17 continued at about the same rate which has prevailed since Service Order No. 5 became effective. The total tonnage of bituminous coal dumped at Lake Erie ports

was 603,808, of which 569,165 tons were cargo coal and 34,643 tons vessel fuel. Shipments during the corresponding week last year were 920,184 tons.

Total shipments from the beginning of the season to July 17 were 5,288,000 tons, compared with 10,374,000 tons in 1918 and 11,849,000 tons in 1919. The Lake movement is thus over five million tons behind 1918 and six and a half million tons behind 1919.

The distribution of the limited cargo tonnage actually dumped at Lake Erie ports during the present season has closely resembled that of the year 1918. Of the 3,567,000 tons dumped up to June 30, 1920, over one-fourth (26.1 per cent) were to Canada, as compared with 24.6 per cent in 1918 and 17.5 per cent in 1919. The proportion sent to American Lake Superior ports, this year, 37.5 per cent, is slightly smaller than in 1918, and much smaller than the very heavy shipments of 1919. Shipments to Canadian Lake Superior ports have also been smaller.

Shipments to Lake Michigan have been proportionately smaller and those to points on Lake Ontario and the St. Lawrence proportionately larger than before. The only destinations to receive absolutely as well as relatively more than formerly were Port Huron and points on the American side of the Detroit River. The increased water shipments to these points—227,000 tons, as against 98,000 in 1918—are in line with a reported increase in rail shipments to Southern Michigan.

The rail movement of bituminous coal to New England during the first three weeks of July has shown a marked increase over the June average, and also over the corresponding period of 1919. The number of cars forwarded to New England destinations through five Hudson gateways—Harlem River, Maybrook, Albany, Rotterdam, and Mechanicsville—during the week of July 17, is reported at 6154. In the second week of June, it had declined to 2817 cars. In the week of July 19, 1919, the cars forwarded numbered 3682.

Comparison of the yearly rate of production for the first half of 1920, with the record for the three years preceding, brings out strikingly the fact that the under production which has marked 1920 has centered in the industrial Northeast.

The fields of the interior have closely approached the 1918 rate, and the Eastern Interior region—Illinois, Indiana, and Western Kentucky, have exceeded the 1917 rate.

Shipments of bituminous coal to tidewater during June were the largest in any month of record. The total dumped at the four North Atlantic ports and Charleston was 4,699,000 net tons, an increase over October, 1919—hitherto the maximum month—of 102,000 tons. The achievement was the more remarkable in view of temporary embargoes on eastbound shipments laid by carriers serving these ports which were necessitated by fresh outbreaks of the switchmen's strike.

The record for the month shows little change in the relative proportions of the New England and export movement. Service Order No. 6 did not go into effect until June 24, so that the month's performance can not be regarded as a test of the effectiveness of that order. The amount shipped coastwise to New England is reported as 772,000 tons, almost exactly the same as during April and May. There was a slight increase in the balance available for other coastwise and local use and for bunker, the total for these purposes amounting to 1,752,000 tons. The greater part of the increase in total dumpings, however, went to exports, which reached 2,175,000 short tons. This was the largest in any month in the history of the country.—Prepared by F. G. Tryon, of the U. S. Geological Survey.

Program of the N. A. S. E. Convention

AN interesting and instructive program has been arranged for the national convention of the National Association of Stationary Engineers which will be held in Milwaukee, Wis., during the week of Sept. 12. Aside from regular business of the association there have been planned excursions to many industrial plants of the city, some entertainment feature for each day and the presentation and discussion of educational papers. The exhibit hall will be open for the inspection of power plant equipment and supplies each day of the convention. Following is the program:

Sunday, Sept. 12, 10 a. m.: Annual convention of the Wisconsin State Association at the Republican House.

Monday, 9 a. m.: Business session of the Wisconsin State Convention.

9 a. m.: Official registration of officers, delegates and visitors to the national convention at the Milwaukee Auditorium.

2 p. m.: Visit to some of the Milwaukee industries.

8 p. m.: Opening of the Mechanical Exposition at the Auditorium, convention committee chairman, Charles F. Bindrich, presiding. Address by Horace A. Smith, president of the National Exhibitors' Association. Address by John H. Moss, of the Milwaukee Association of Commerce. Address by John J. Calahan, president of the National Association of Stationary Engineers. Band concert in Exhibit Hall.

Tuesday, 10 a. m.: Opening exercises of the convention in the Auditorium, Chas. F. Bindrich presiding. Addresses by Governor E. L. Phillips, John J. Calahan, Mayor Daniel W. Hoan, National Vice-President Alfred Johnson, Phil A. Grau, general secretary of the Milwaukee Association of Commerce and Past President Roderick McKay.

Official opening of the convention by National President John J. Calahan, and the appointing of convention committees.

1:30 p. m.: First business session of the convention in Juneau Hall, Auditorium, where all business sessions will be held.

3 p. m.: Lecture, "Science and Engineering," by Ben S. Elliott, professor of mechanical engineering, University of Wisconsin.

4 p. m.: Annual meeting of the Life and Accident Depart.

4 p. m.: Visit to some Milwaukee industry.

9 p. m.: A very interesting program is being arranged to take place at the Auditorium.

Wednesday, 9 a. m.: Second business session convention.

10:30 a. m.: Lecture, "Importance of the Operating Engineer," by H. B. Wilder, of Detroit, Mich.

1 p. m.: Field Day, including baseball, horse races,

boat races, running races, and outdoor sports and entertainment of every description, at Washington Park, Milwaukee's most beautiful recreation spot, given under the auspices of the Milwaukee Association of Commerce.

8 p. m.: Moving pictures of industries of Milwaukee at the Auditorium.

Thursday, 9 a. m.: Third business session of the convention.

10:30 a. m.: Lecture, "Thermometer and Pyrometer in the Power Plant," by W. J. Neely, of Chicago.

11:15 a. m.: Official visit to convention by the Ladies' National Auxiliary.

11.30 a. m.: Memorial services.

1:30 p. m.: Fourth business session of the convention.

3 p. m.: Topical discussion on "Capacity and Maintenance Costs," opened by Charles A. Cahill, consulting engineer, Milwaukee, Wis.

A specially provided program is being prepared for visiting ladies' comfort and pleasure.

4:30 p. m.: Visit to some Milwaukee industry.

8 p. m.: National Exhibitors' Association annual entertainment at the Auditorium.

Friday, 9 a. m.: Fifth business session of the convention.

8 p. m.: Public installation of officers and annual ball at Auditorium.

Civil Service Examinations

U. S. Civil Service Commission announces examinations for the following: Engineer, $2400, or over, a year, Assistant Engineer, $1800 to $2340 a year; Junior Engineer, $1440 to $1740 a year. Vacancies in the Water Resources Branch of the Geological Survey, at the salaries indicated, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from these examinations. In addition, employes will be allowed expenses when on field duty. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. On account of the needs of the service, papers will be rated promptly and certification made as the needs of the service require. In the absence of further notice, applications for these examinations will be received by the commission at Washington, D. C., until the hour of closing business on Dec. 1, 1920. If sufficient eligibles are obtained, the receipt of applications may be closed before that date, of which due notice will be given. Applicants for the positions of engineer and assistant engineer must have reached their twenty-fifth birthday on the date of making oath to the application, and applicants for the position of junior engineer must have reached their twentieth but not their thirty-fifth birthday on such date. Age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating the title of the examination desired.

American Society of Mechanical Engineers has established a "professional section on material handling" with the avowed purpose of encouraging the mechanical handling of materials of all kinds; movement is said to be gaining ground rapidly because of high cost of labor.

Pulverized Coal Plant Explodes

From some unknown cause, the pulverized coal plant of the Mansfield Sheet & Tin Plate Co., Mansfield, O., exploded at 9:30 a. m. on July 22, causing the death of four men and serious injury to five others; the building and machinery, however, were not damaged.

Those who met death were Frank Kyne, E. L. Derr, Sam La Lass and Lester Harding; those seriously injured are Amos Watts, J. C. Tansnaugh, Harold Kinyon and George Robinson.

The pulverized coal plant is situated midway between the north and south plants of the company and has been in use for the past 2 yr. The fuel is used in 14 furnaces, the hot mills and for annealing the steel.

At the time of the explosion, a workman was installing some new machinery. Without any warning, a big puff occurred and a sheet of flame broke out all over the building, lasting only an instant, except for smoldering powdered coal which in spite of the efforts of the fire department still showed traces of fire after several hours. Several theories have been advanced as to the cause of the explosion, but the most plausible seems to be spontaneous combustion.

Trade News

The Chicago Pneumatic Tool Co. has recently issued Bulletin 504, which describes the Slogger rock drill and is available to anybody interested upon request.

Flexible Shafting Bulletin No. 20, describing, in addition to Stow flexible shafting, a number of tools used in connection with it, was lately received from Stow Manufacturing Co., Inc., Binghamton, N. Y.

Niagara Conoidal fans catalog No. 421 contains tables of performances that will enable fan selections to be made to meet any demands met in ordinary heating and ventilating practice. The manufacturer is Buffalo Forge Co., Buffalo, N. Y.

Golden-Anderson Valve Specialty Co.'s latest illustrated catalog of automatic cushioned valves for steam and water service contains 176 pages listing many new styles of valves. The manufacturer's main offices are in the Fulton Building, Pittsburgh, Pa.

Pulmore Pulley Tread, a chemically treated fiber compressed into sheet form and easily applied to any kind of pulley by soaking in water for a few seconds, is the subject discussed in Bulletin No. 201 of The Colegrove-Greenwood Co., Cleveland, O.

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has issued leaflets which describe and illustrate its line of oil circuit-breakers. Both the application and distinctive features of these circuit-breakers are discussed. Each leaflet contains a table, giving an outline of maximum current, voltage and interrupting capacity ratings of the circuit-breakers listed.

The company is also distributing miniature catalog 9-A-2, which describes industrial heating apparatus.